

Common Material Foundation of Gravitation Theory and Quantum Theory

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To cite this article:

Zhou Shuwen. Common Material Foundation of Gravitation Theory and Quantum Theory. *American Journal of Modern Physics*. Vol. 7, No. 3, 2018, pp. 103-115. doi: 10.11648/j.ajmp.20180703.11

Received: April 26, 2018; **Accepted:** June 4, 2018; **Published:** June 29, 2018

Abstract: In order to unite gravitational field with other fields, we must find the common material foundation of the gravitation theory and quantum theory. For the end, I propose the duality framework of the universe. The universe is composed of continuous universal continuum and separate p net; Universal energy E_u and various special energies E_s that transform into one another at high frequency; Basic forces that dominate the universe are the universal compressive force and quantum dispersive force. The above duality framework, can explain naturally the wave-particle duality, probabilistic nature, uncertainty relation and quantum entanglement; no using Einstein's theory, can obtain the mass-energy relation, Einstein's equations, Friedmann's equation and the proportions of dark energy, dark matter and ordinary matter; includes, links and foreruns both the gravitation theory and quantum theory; is their common material foundation to give their unified harmonious image; and can solve the puzzlers about the singularity, non-locality, uncertainty of energy, et al. Daring predictions: The electromagnetic wave must have an adjoint strain wave. The gravitational wave must have an adjoint wave of matching field. It is in the wrong direction to find the particle of the "dark matter".

Keywords: Quantum Dispersive Force, Universal Compressive Force, Universal Lump Elasticity, $E_u \leftrightarrow E_s$ High Frequency Transformation, Complex Field

1. Introduction

Regarding the gravitational theory, quantum theory and universal theory, it can be said that currently a hundred schools of thought is contending for their advancement [1-8, 23-32]. What is the material foundation of the space? What is the essence of the wave-particle duality? What is the basic action in universe? All the problems are not clear. We meet with the puzzlers about the singularity, non-locality, uncertainty of energy, et al. For the end, our task is to find the common material foundation of the gravitation theory, quantum theory and universe theory to give their unified harmonious image.

1.1. Hypothesis on Duality

(1) The universe is made up of the continuous universal continuum and the separate P chamber network embedded therein [5, 6]. The vacuum state P chamber radius is $r_p = (\hbar G/c^3)^{1/2}$, the quantum charge is $(\hbar c)^{1/2}$ [8, 9] and mass is

$m_p = (\hbar c/G)^{1/2}$. The interior of the P chamber is described with the multi-D superspace. The universal lump has elasticity [9, 44]. The elastic modulus is $E_e = (Gm_p^2/r_p^2)/(4\pi r_p^2) = (c^4/G)/4\pi r_p^2$. The universe continuum is described with Riemann's geometry.

(2) There are two classes of motion and energy in the universe [7]. One is the E_u energy possessed by each and every particle, $E_u \propto m_u$. E_u is distributed in the universal continuum to form the U field. The other class are the E_s energies possessed by various special forms of motion, $E_s = \sum_i E_{si}$

$E_{si} \propto m_{si}$, such as electromagnetic motion, flavor motion, color motion. The E_s is only distributed in the P chamber. The E_u and E_s of each particle are transformed into each other at high frequency, while $E_T = E_u + E_s$ remains unchanged. The kinetic energy E_k is $E_u \cap E_s$.

(3) Two basic actions [8]. Vacuum is the equilibrium state of E_u and E_s with the lowest energy. When there is excited dm_u superimposed in the universal continuum outside the P

chamber, vacuum will give it universal compressive force $dF_u=(Gm_p/r_p^2)dm_u$ that compresses it back into a certain P chamber and changes into E_s . When there is excited dm_s superimposed in the p chamber, vacuum will give it quantum

dispersive surface force $dF_q=(Gm_p/r_p^2)dm_s$ that compresses it back into the universal continuum and changes into E_u . When the E_s excited in the P net is captivated in a sphere with radius r , quantum dispersive surface force $\hbar c/r^2$ will be generated [9].

1.2. Duality Framework

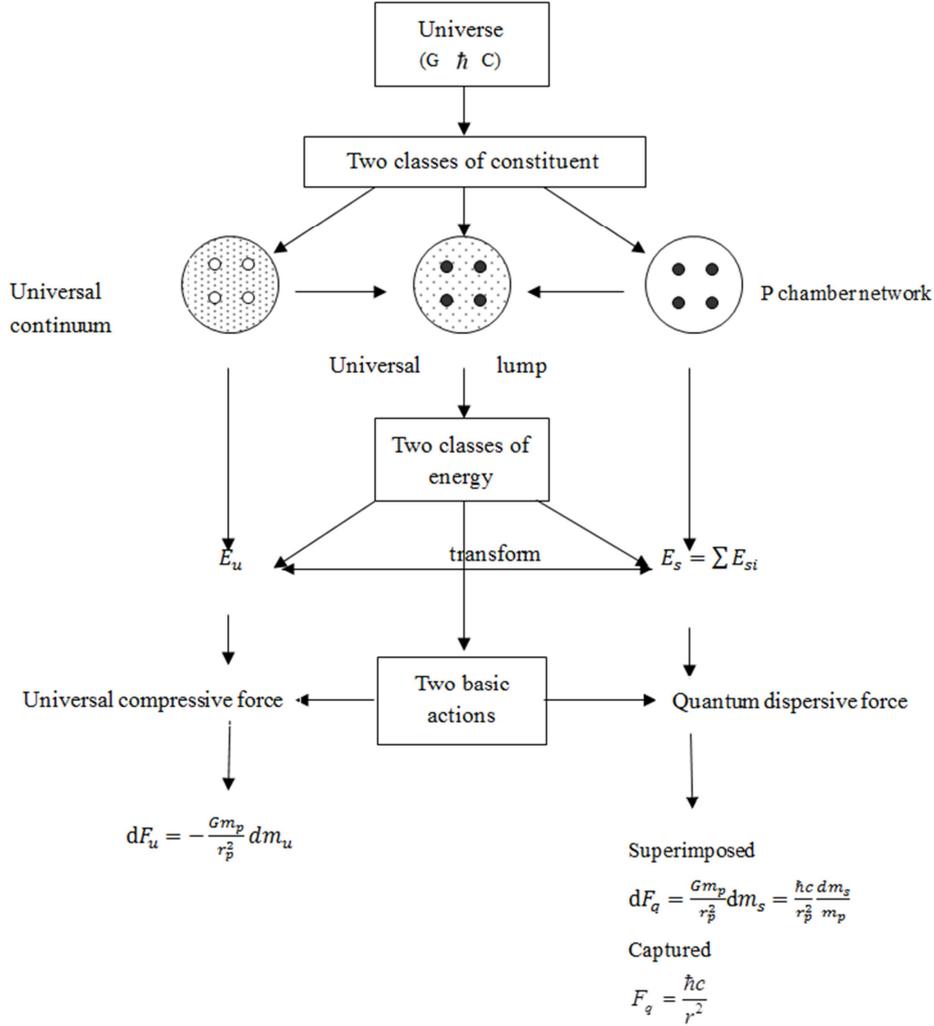


Figure 1. Duality framework.

1.3. Generalized Coordinates

For an isotropic homogeneous elastomer sphere, under the action of elastic surface force, when the variation of volum $\Delta V \ll V$, the equation of motion can be written as

$$m \frac{d^2}{dt^2} q_V = -K q_V \tag{1}$$

$$q_V \equiv r_e \Sigma_V \tag{2}$$

$$\Sigma_V \equiv \frac{V - V_0}{V_0} \tag{3}$$

where m is the sphere's equivalent mass, r_e and V_0 are the radius and volume in equilibrium state, and k is the elastic constant in volume deformation, Σ_V the relative variation in

volume, q_V the generalized coordinate. $-kq_V$ is the elastic surface force.

The generalized coordinates are defined as whatever quantities that can define unique "position" of the system in "space". The morphology of Lagrangian equation has nothing to do with the choice of the coordinate. We popularize the generalized coordinate to the universal lump spheres acted on only by the surface forces F_q and F_u .

Definitions

$$q \equiv r_e \Sigma \tag{4}$$

$$\Sigma \equiv \frac{\Delta u}{u_0} \tag{5}$$

where r_e is the characteristic radius of the system in equilibrium state, u the physical quantity describing the state

of the system while Δu is the deviation of u from equilibrium state. u_0 is the absolute value of equilibrium value, Σ is the relative variation of u .

The system's Lagrangian function is

$$L = \frac{1}{2} m \dot{q}^2 - E_p(q) \tag{6}$$

Further,

$$\frac{\partial L}{\partial q} = -\frac{\partial E_p}{\partial q} = F(F_q, F_u). \tag{7}$$

Lagrangian equation can be written as

$$m r_e \frac{d^2}{dt^2} \Sigma = F(F_q, F_u). \tag{8}$$

2. E_u and E_s Oscillation of the P Sphere

2.1. P Sphere Mechanical System

The P chamber constitutes a mechanical system with its surrounding universal continuum, or P sphere for short. The vacuum state P chamber's mass, energy and radius are m_p , E_p , r_p , respectively. The excited energy E_s and E_u , are distributed in the chamber and in the universal continuum outside the chamber, respectively.

For simplicity, Let us assume that vacuum is the static equilibrium state, E_p not enters into the energy transformation. Definitions:

$$\Sigma_p \equiv \frac{E_u - E_s}{E_p}, \tag{9}$$

$$q_p \equiv r_e \Sigma_p = r_p \left(\frac{E_u - E_s}{E_p} \right). \tag{10}$$

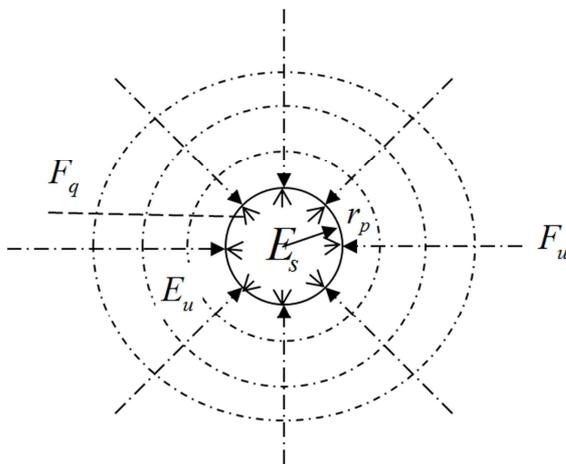


Figure 2. P sphere acted on by surface forces.

As show in figure 2, the interior and exterior of the p chamber interface bear the surface forces of F_q and F_u , respectively.

$$F_p = -\frac{Gm_p}{r_p^2} m_u + \frac{\hbar c}{r_p^2} \frac{m_s}{m_p} = -\frac{Gm_p^2 (m_u - m_s)}{r_p^2 m_p} \tag{11}$$

$E \ll m$, so

$$F_p = -\frac{Gm_p^2 (E_u - E_s)}{r_p^2 E_p} \tag{12}$$

2.2. Equations of Motion

The P spheres equations of motion is

$$m_p r_p \frac{d^2}{dt^2} \left(\frac{E_u - E_s}{E_p} \right) = -\frac{Gm_p^2 (E_u - E_s)}{r_p^2 E_p} \tag{13}$$

$$\frac{d^2}{dt^2} \left(\frac{E_u - E_s}{E_p} \right) = -\omega_p^2 \left(\frac{E_u - E_s}{E_p} \right), \omega_p^2 = \frac{c^5}{\hbar G}. \tag{14}$$

The Lagrangian function is

$$L_p = \frac{1}{2} m_p \dot{q}_p^2 - \frac{1}{2} m_p \omega_p^2 q_p^2 \tag{15}$$

The solutions are

$$E_u = \frac{E_T}{2} (1 - \cos \omega_p \tau), \tag{16}$$

$$E_s = \frac{E_T}{2} (1 + \cos \omega_p \tau), E_s = \sum_i E_{si} \tag{17}$$

$$E_T = E_u + E_s = 2\overline{E_u} = 2\overline{E_s}. \tag{18}$$

2.3. E_u and E_s Oscillation of Particle

(1) The energy becomes E_s upon entering the P chamber via the interface and becomes E_u when emitted out transforming at high frequency. The particle is localized (E_s), also nonlocalized (E_u). Each particle is possessing of the total energy $E_T = 2\overline{E_u} = 2\overline{E_s}$, what we have obtained by U means measurement or S means is but the mean value $\overline{E_u}$ or $\overline{E_s}$.

(2) In $E_u \leftrightarrow E_s$ oscillation, the universe lump is deformed but without much move. Energy E_u is transmitted with superluminal speeds, just like electric energy is transmitted in a conductor with a speed exceeding that of electrons move. The P network doesn't move. By the move of particle is meant the excited energy E_s transforming via E_u from a P chamber pressed into another probabilistically that is the jump of E_s energy. This is just like the "jump" of flashing jumpingly bulb with no move of the bulbs. The average speed of a long period of probability jump of E_s in the P network is $\bar{u} \leq c$.

(3) Regarding the character of probability: After energy E_s changes into E_u and back to E_s again, what P chamber is it after all that it has returned to is probabilistic, with the probabilistic density proportional to the E_u 's energy density ρ_u at that. In the P chamber, within $E_u \rightarrow E_s$ on the premise of conservation of the relevant physical quantity, what is the E_{si} that has been converted into is also probabilistic. The character of probability in quantum mechanics originates in the highly frequent transformation $E_u \leftrightarrow E_s$.

3. U Field in the Universal Continuum

3.1. Universal Lump Elasticity

(1) The action of P chamber on universal continuum

The E_u and E_s are transformed into each other at high frequency. The average of a long period is corresponding to the value of the static equilibrium.. According to above, the

universal lump in vacuum state is an isotropic homogeneous elastomer, a single P chamber excited state excites spherically symmetrical gravitational field, or U field for short. As shown in figure 3, in the spherical layer (r_p-r), its inner surface bears the quantum dispersive force in the P chamber, that is, $F_q=(Gm_p/r_p^2)(m_p+m_s)$; while the outer surface bears the universal compressive force $F_u = \sigma_{rr}^T 4\pi r^2$

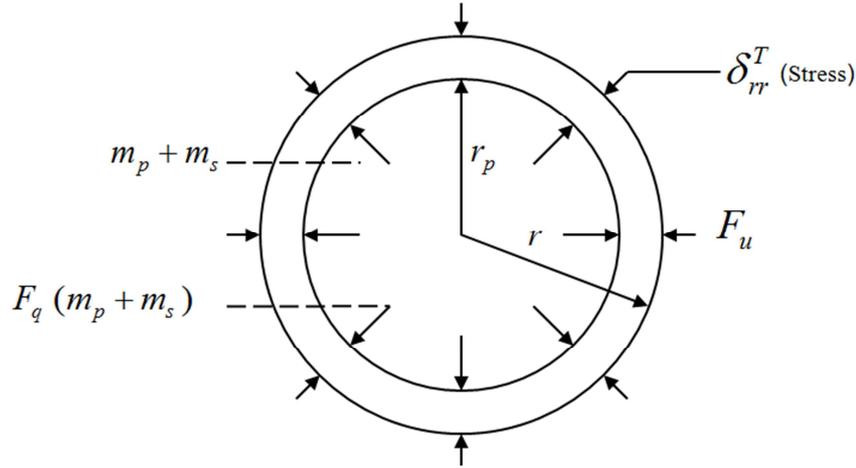


Figure 3. Universal lump spherical layer acted on by surface forces.

The static equilibrium equation is

$$\frac{Gm_p}{r_p^2}(m_p + m_s) + \sigma_{rr}^T 4\pi r^2 = 0, \quad (19)$$

Further

$$\sigma_{rr}^T = -\frac{Gm_p^2}{4\pi r_p^2} \left(1 + \frac{m_s}{m_p}\right) r^{-2} \quad (20)$$

The universal lump elastomer's Hooke equation is

$$\mathcal{E}_{rr}^T = E_e^{-1} \sigma_{rr}^T. \quad (21)$$

Strain and displacement are

$$\mathcal{E}_{rr}^T = -\frac{r_p^2}{r^2} \left(1 + \frac{m_s}{m_p}\right), \quad u_r^T = r_p \frac{r_p}{r} \left(1 + \frac{m_s}{m_p}\right). \quad (22)$$

$$E_u(m_s) = \int_{r_p}^{\infty} \frac{Gm_p m_s}{4\pi r^4} \cdot 4\pi r^2 dr = m_s C^2 = m_u \sqrt{G} \cdot \frac{C^2}{\sqrt{G}} = m_s \sqrt{G} \frac{\sqrt{\hbar c}}{r_p} = \frac{m_s}{m_p} \sqrt{\hbar c} \cdot \frac{\sqrt{\hbar c}}{r_p} \quad (25)$$

Where $m_s = m_u = m$ [see Eq.(18)].

That is, mc^2 is the potential energy interacted between mass charge $m_u G^{1/2}$ and vacuum potential $c^2/G^{1/2}$, or that between quantum charge $(m_s/m_p)(\hbar c)^{1/2}$ and vacuum potential $(\hbar c)^{1/2}/r_p$. The relativity only has the result mc^2 , but not the explanation on the mechanism. The opinion on the transformation of the mass and energy is mistaken. The rest energy of the elementary particle is $E_T = E_u + E_s = 2mc^2$ [see Eq.(18)].

Similarly, we have

$$\sigma_{rr}^T(m_s) = -\frac{Gm_p m_s}{4\pi r_p^2 r^2}, \quad (26)$$

The density of universal continuum elastic energy is

$$\rho_u^T(m_p + m_s) = \frac{1}{2} E_e^{-1} (\sigma_{rr}^T)^2 = \frac{Gm_p^2}{8\pi r^4} + \frac{Gm_p m_s}{4\pi r^4} + \frac{Gm_s^2}{8\pi r^4} \quad (23)$$

where $Gm_p^2/(8\pi r^4)$ will find the sum of P chambers of the entire universe to obtain vacuum energy density.

The excited energy density is

$$\rho_u = \frac{Gm_p m_s}{4\pi r^4} \left(1 + \frac{m_s}{2m_p}\right) \approx \frac{Gm_p m_s}{4\pi r^4}. \quad (24)$$

The excited energy is

$$\mathcal{E}_{rr}^T(m_s) = -\frac{r_p^2 m_s}{r^2 m_p}, \quad (27)$$

$$u_r^T(m_s) = \frac{r_p}{r} \frac{m_s}{m_p}. \quad (28)$$

(2) The interaction between excited energy flow and vacuum background

Vacuum has pressure on the excited energy $E_u(\rho_u)$, trying hard to press it into a certain P chamber and become E_s . As shown in figure 4, the compressive force generated by

spherical layer $(r_a - r_b)$ under the action of vacuum is

$$F_u(r_a - r_b) = \int_{r_a}^{r_b} -\frac{Gm_P}{r_P^2} \cdot \frac{Gm_P m_s}{4\pi r^4 c^2} \cdot 4\pi r^2 dr = -m_s c^2 \left(\frac{1}{r_a} - \frac{1}{r_b} \right) \quad (29)$$

$$F_u(r - \infty) = -\frac{m_s c^2}{r} \quad (30)$$

Stress

$$\sigma_r^r = -\frac{m_s c^2}{r} \cdot (4\pi r^2)^{-1} = -\frac{m_s c^2}{4\pi r^3} \quad (31)$$

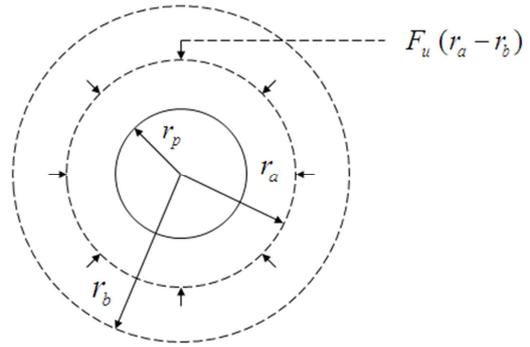


Figure 4. Excited energy spherical layer acted on by surface forces.

The spherically symmetric stress tensor [10]

$$\sigma_v^\mu(u) = \text{diag} \left[-\frac{m_s c^2}{4\pi r^3}, \frac{m_s c^2}{8\pi r^3}, \frac{m_s c^2}{8\pi r^3}, -\frac{m_s c^2 r_P}{4\pi r^4} \right] = T_v^\mu(u) \quad (32)$$

When vacuum background gives the excited energy flow $\sigma_v^\mu(u)$, reaction is obtained at the same time.

$$\sigma_v^\mu(B) = \text{diag} \left[\frac{m_s c^2}{4\pi r^3}, -\frac{m_s c^2}{8\pi r^3}, -\frac{m_s c^2}{8\pi r^3}, -\frac{m_s c^2 r_P}{4\pi r^4} \right] = T_v^\mu(B) \quad (33)$$

From Hooke's equation we have

$$\varepsilon_v^\mu(B) = E_e^{-1} \sigma_v^\mu(B) = \text{diag} \left[\frac{r_P^2 G m_s}{c^2 r^3}, -\frac{r_P^2 G m_s}{2c^2 r^3}, -\frac{r_P^2 G m_s}{2c^2 r^3}, -\frac{r_P^2 G m_s r_P}{c^2 r^4} \right] \quad (34)$$

3.2. Curvature of the P Chamber

(1) Image

Under the reaction of the excited energy flow, the vacuum background P chamber is stretched along the \hat{r} direction and contracted transversely, as shown in figures 5, 6, and 7.

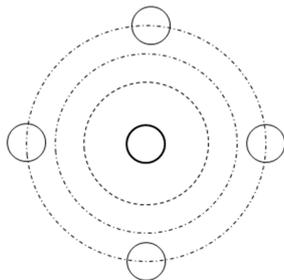


Figure 5. Vacuum state spherical P chamber.

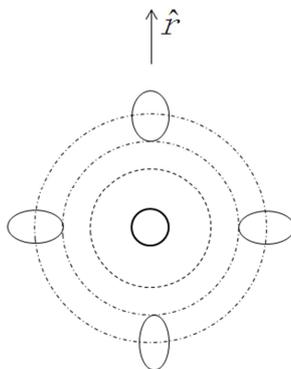


Figure 6. Excited ellipsoidal P chamber.

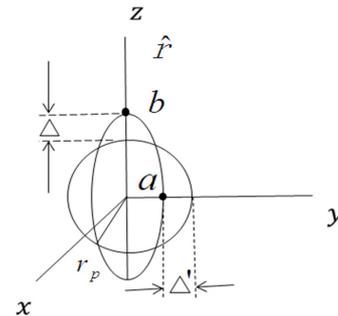


Figure 7. Ellipse.

(2) The curvature tensor

As shown in figure 7, the linear curvature at point b of ellipse is

$$c_b = \frac{b}{a^2} = \frac{r_P + \Delta}{(r_P + \Delta')^2} = \frac{1}{r_P} \left(1 + \frac{\Delta}{r_P} \right) \quad (35)$$

where $\Delta = \varepsilon_r^r(B) r_P$, $\Delta' = 0$ ($u_\theta = u_\phi = 0$).

The surface curvature at point b of the ellipsoid is

$$c_b^2 = \frac{1}{r_P^2} \left(1 + \frac{\Delta}{r_P} \right)^2 \cong \frac{1}{r_P^2} \left(1 + 2 \frac{\Delta}{r_P} \right) = \frac{1}{r_P^2} + \frac{2\Delta}{r_P^3} \quad (36)$$

The surface curvature increment at point b is

$$c_b^2 - \frac{1}{r_P^2} = \frac{2\Delta}{r_P^3} \quad (37)$$

The \hat{r} directed curvature increment is

$$(c_b^2 - \frac{1}{r_p^2}) = \frac{2\Delta}{r_p^3} = \frac{2\varepsilon_r^r(B)}{r_p^2} = \frac{2Gm}{c^2 r^3}. \quad (38)$$

It is usually considered that the space-time of vacuum is flat. If so, the 3-D spatial curvature $(R_r^r)_a$ [11] is in effect P chamber's \hat{r} directed curvature increment $[c_b^2 - (1/r_p^2)]$.

$$(R_r^r)_a = (c_b^2 - \frac{1}{r_p^2}) = \frac{2\Delta}{r_p^3} = \frac{2\varepsilon_r^r(B)}{r_p^2} = \frac{2Gm}{c^2 r^3}. \quad (39)$$

This is exactly Schwarzschild's solution for $(R_r^r)_a$, but we give the clear elasticity image on the curvature.

3.3. Elastic Statement of Gravitation Equation

From Eq. (38) and Hooke's equation we have

$$\Sigma_r^r(\text{curvature}) \equiv \left(c_b^2 - \frac{1}{r_p^2}\right) \left(\frac{2}{r_p^2}\right)^{-1} = (R_r^r)_a \left(\frac{2}{r_p^2}\right)^{-1} = \varepsilon_r^r(B) = E_e^{-1}(T_r^r(B))_a. \quad (40)$$

$$(R_r^r)_a = \frac{2}{r_p^2} E_e^{-1}(T_r^r(B))_a = \frac{8\pi G}{c^4} (T_r^r(B))_a \quad (41)$$

Similarly, we have

$$(R_\theta^\theta)_a = \frac{8\pi G}{c^4} (T_\theta^\theta(B))_a, \quad (42)$$

$$(R_\phi^\phi)_a = \frac{8\pi G}{c^4} (T_\phi^\phi(B))_a. \quad (43)$$

The static spherically symmetric 3-D curvature equations are

$$(R_i^i)_a = \frac{8\pi G}{c^4} (T_i^i(B))_a \quad i=1,2,3. \quad (44)$$

The non-spherically symmetric 4-D ordinary case should be

$$G_v^\mu = \frac{8\pi G}{c^4} T_v^\mu(B), \quad \mu, \nu=1,2,3,4. \quad (45)$$

There should be $G_{v,\mu}^\mu=0$ on the left side of equations (45) as $T_{v,\mu}^\mu=0$ on the right. For this reason, there must be $G_v^\mu = R_v^\mu - \frac{1}{2} \delta_v^\mu R$. Ordinarily curvature equations are

$$R_v^\mu - \frac{1}{2} \delta_v^\mu R = \frac{8\pi G}{c^4} T_v^\mu(B), \quad (46)$$

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^4} T_{\mu\nu}(B). \quad (47)$$

It should be emphasized that $T_{\mu\nu}$ in Einstein's equations is of field source, of E_s and forced on it by conjecture while $T_{\mu\nu}(B)$ in equations (47) is E_u 's and continuously distributed in and outside the "source" and an inevitable result of the elastomer's Hooke equation. Einstein's equations are only Hooke's equations of the universal lump in linear approximation.

3.4. Correlation Between Elastic Statement, Geometric Statement and Field Statement

Geometric statement

$$g_{rr} = (1 + \frac{2Gm_s}{c^2 r}) = (1 + \frac{2u_r^T(m_s)}{r_p}), \quad (48)$$

$$g_{44} = (1 - \frac{2Gm_s}{c^2 r}) = (1 - \frac{2u_r^T(m_s)}{r_p}), \quad (49)$$

$$\Gamma_{rr}^r = -\frac{Gm_s}{c^2 r^2} = \frac{\varepsilon_{rr}^T(m_s)}{r_p}, \quad (50)$$

$$(R_r^r)_a = \frac{2Gm_s}{c^2 r^3} = \frac{2\varepsilon_r^r(B)}{r_p^2}, \quad (51)$$

$$R = \frac{8\pi G}{c^4} \rho_u(m_s). \quad (52)$$

Field Statement

$$c^2 = \frac{Gm_p}{r_p}, \quad (53)$$

$$\varphi = -\frac{Gm_s}{r} = -\frac{c^2 u_r^T(m_s)}{r_p}, \quad (54)$$

$$\Phi = c^2 - \frac{Gm_s}{r} = \frac{Gm_p}{(r_p + u_r^T(m_s))} = \frac{Gm_p}{r_p} (1 - \frac{u_r^T(m_s)}{r_p}) \quad (55)$$

$$\vec{E} = \frac{-Gm_s}{r^2} \hat{r} = \frac{Gm_p}{r_p^2} \varepsilon_{rr}^T(m_s) \hat{r}. \quad (56)$$

3.5. Origin of the Newtonian Gravitation



Figure 8. Deformation of the universal lump at a certain point in the weakened region has to bend both toward P_1 and P_2 , hence mutual weakening.

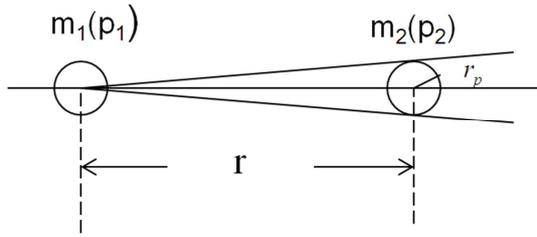


Figure 9. Particle equivalent cross section is $4\pi r_p^2$, the corresponding solid angle is $\Omega = \frac{4\pi r_p^2}{r^2}$.

$$F_u(1) = \frac{Gm_p m_1}{r_p^2} :$$

The universal continuum total surface force borne by the P chamber's outer surface of the isolated particle 1. The resultant is now zero.

$$\frac{Gm_p m_1}{r_p^2} \cdot \frac{1}{4\pi}$$

The universal continuum's force on the surface of P₁ chamber in unit solid angle.

$$\frac{Gm_p m_1}{r_p^2} \cdot \frac{1}{4\pi} \cdot \frac{4\pi r_p^2}{r^2}$$

The universal continuum's force on the surface of P₁ chamber in the solid angle $4\pi r_p^2/r^2$ formed by P₂ chamber.

$$\frac{Gm_p m_1}{r_p^2} \cdot \frac{1}{4\pi} \cdot \frac{4\pi r_p^2}{r^2} \cdot \frac{m_2}{m_p} = \frac{Gm_1 m_2}{r^2}$$

The cut down amount of the force borne by P₁ chamber surface via weakening by m₂ at r in the solid angle $4\pi r_p^2/r^2$, the cut down rate of m₂ is m₂/m_p.

The Newtonian gravitation F_G:

For isolated particle, the resultant force of universal continuum on P chamber is zero. When there are two particles, because of mutual weakening, the resultant is not zero but expressed as $\frac{Gm_1 m_2}{r^2} \hat{r}$, $-\frac{Gm_1 m_2}{r^2} \hat{r}$, respectively. The Newtonian gravitation F_G is the result of destruction of F_u

spherical symmetry, $-\frac{Gm_1 m_2}{r}$ is reduction in potential energy $E_u = (m_1 + m_2)c^2$, $\frac{Gm^2}{8\pi r^4}$ only is a part of $\rho_u = G \frac{m_p m}{4\pi r^4} + G \frac{m^2}{8\pi r^4}$.

4. Q Field in P Chamber Network

4.1. C sphere's Mechanical System

The surface forces F_u and F_q in equilibrium constitute a C sphere as shown in figure 10.

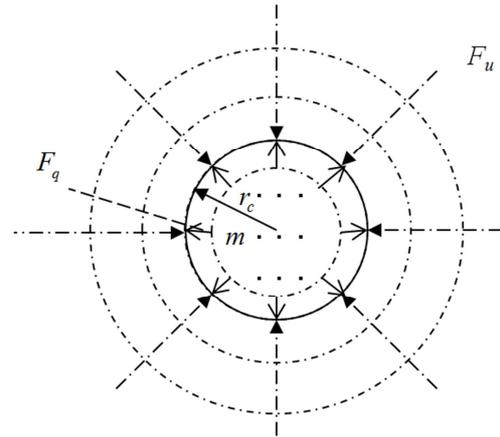


Figure 10. C sphere acted on by surface forces.

On the interface of the C sphere [8], $-mc^2/r_c + \hbar c/r_c^2 = 0$, the particle is captivated in the C sphere jumping probabilistically. The C sphere and surrounding universal continuum constitute a mechanical system. The mass of C sphere is m, its radius is $r_c = \hbar/(mc)$, E_s distributed in the P chamber jumping probabilistically, i.e. in the C sphere, E_u distributed in the universal continuum in and outside the C sphere. The excited energy E_T=E_u+E_s makes the system deviate from the vacuum state and generate the quantum field ψ , or Q field for short. Its relative change is $\Sigma_c \equiv \psi/|\psi_v|$, $|\psi_v|$ is the mode of the vacuum state function that is a constant. The generalized coordinate of the system is $q_c = r_c \psi/|\psi_v|$.

Let's turn back to P chamber acted on by force F_p= $-(Gm_p^2/r_p^2)[(E_u-E_s)/E_p]$, where Gm_p^2/r_p^2 is the single-side value of the vacuum state P chamber interfacial equilibrium force. $(E_u-E_s)/E_p = \Sigma_p$, Similarly, for C sphere ψ we have

$$F_c = \frac{-\hbar c}{r_c^2} \frac{\psi}{|\psi_v|}, \tag{57}$$

where $\frac{\hbar c}{r_c^2}$ is the single-side value of C sphere equilibrium

force, $\frac{\psi}{|\psi_v|} = \Sigma_c$.

4.2. The Equation of Motion

The equation of motion of ψ is

$$m r_c \frac{d^2}{d\tau^2} \psi/|\psi_v| = -\frac{\hbar c}{r_c} \psi/|\psi_v|, \tag{58}$$

$$\text{or } \frac{d^2 \psi}{d\tau^2} = -\omega^2 \psi, \quad \omega^2 = \frac{m^2 c^4}{\hbar^2}. \tag{59}$$

Lagrangian functions is

$$L_c = \frac{1}{2} m \dot{q}_c^2 - \frac{1}{2} m \omega^2 q_c^2. \tag{60}$$

Further,

$$\frac{d^2}{d\tau^2}\psi_\phi = -\frac{m^2c^4}{\hbar^2}\psi_\phi, \quad (61)$$

$$\frac{d}{d\tau}\psi_D = -i\frac{mc^2}{\hbar}\psi_D. \quad (62)$$

Where ψ_ϕ , ψ_D are the state functions of the scalar particle and that of Dirac particle, respectively.

The field equations are

$$\gamma_\mu \partial_\mu \psi_D = -\frac{mc}{\hbar} \psi_D, \quad (63)$$

$$\gamma_\mu^2 \partial_\mu^2 \psi_\phi = \frac{m^2c^2}{\hbar^2} \psi_\phi, \quad (64)$$

respectively.

4.3. Puzzlers of the Quantum Theory

(1) Material basis of ψ

The wave function ψ is the joint effect of P net and universal continuum in $E_u \leftrightarrow E_s$ oscillation. The wave nature material basis is universal continuum, particle nature material basis is P chamber, probabilistic nature material basis is the high frequency transformation $E_u \leftrightarrow E_s$.

(2) Connection of quantum theory and gravitational theory

The free particle wave function can be represented by the physical quantities ρ_u , R and ε in the U field [12].

$$R = \frac{8\pi G}{c^4} \rho_u, \quad \rho_u = \frac{1}{2} E_e \varepsilon^2.$$

The scalar field

$$\phi = A_\phi \exp[ik_\mu x_\mu], \quad (65)$$

$$A_\phi = \frac{\hbar c}{\sqrt{2EV}} = \left(\frac{\hbar c}{16\pi r_p^2}\right)^{1/2} R^{1/2} = \frac{c^2}{\sqrt{G}} \frac{1}{\sqrt{16\pi}} \frac{r_c}{r_p} \varepsilon, \quad (66)$$

$$\phi^* \phi = \frac{\hbar c}{16\pi r_p^2} R = \rho_u \left[\frac{1}{2} r_c^2\right], \quad (67)$$

$$\frac{8\pi}{R} \cdot \phi^* \phi \frac{2m}{\hbar^2} \cdot mc^2 = \frac{c^4}{G}. \quad (68)$$

The Dirac field

$$\psi = A_D u_{\bar{k}, \sigma} \exp[ik_\mu x_\mu], \quad (69)$$

$$A_D = \frac{1}{\sqrt{V}} \sqrt{\frac{mc^2}{E}} = \left(\frac{1}{8\pi} \frac{r_c}{r_p^2}\right)^{1/2} R^{1/2} = \left(\frac{r_c}{8\pi r_p^4}\right)^{1/2} \varepsilon, \quad (70)$$

$$\bar{\psi} \psi = \frac{1}{8\pi} \frac{r_c}{r_p^2} R = \rho_u \left[\frac{r_c}{\hbar c}\right], \quad (71)$$

$$\frac{8\pi}{R} \cdot \bar{\psi} \psi \cdot mc^2 = \frac{c^4}{G}. \quad (72)$$

The wave function is the wave function of various special field, is also the strain (stress) wave function. The electromagnetic wave must have an adjoint strain wave.

(3) Quantum entanglement

Electron 1 and electron 2 constitute the quantum state

$|\psi\rangle = \frac{1}{\sqrt{2}} [|\uparrow\rangle_1 |\downarrow\rangle_2 - |\downarrow\rangle_1 |\uparrow\rangle_2]$ with zero spin, whose

physical essence is, by means of action, to enable two electrons to possess a common E_u , in collaboration the common E_u with E_s (1) and E_s (2) carries out $E_u \leftrightarrow E_s$ oscillation synchronously. $|\uparrow\rangle$, $|\downarrow\rangle$ randomly assigned but ensuring conservation of angular momentum. When the two electrons in entangled state are set far apart, despite the absence of conventional mechanical action, they can still be entangled via their E_u in common (not Newtonian gravitation). If $|\uparrow\rangle$ is found here, then $|\downarrow\rangle$ will certainly be found far away. This is no instantaneous action but the fact that the E_u common to $|\uparrow\rangle$ and $|\downarrow\rangle$ has all along had them coupled. That is Feynman's expectation [12].

(4) Uncertainty relation of the energy

If we measure E_s by means of s , we are not able to find the instantaneous value but just the average value in an interval Δt :

$$E_s = \frac{1}{\Delta t} \int_0^{\Delta t} \frac{E_T}{2} (1 + \cos \omega_p t) dt = \frac{E_T}{2} + \frac{E_T}{2} \frac{\sin \omega_p \Delta t}{\Delta t \omega_p} \quad (73)$$

The true vacuum is the dynamic equilibrium state, E_p enters into the energy transformation. Where $E_T = 2\hbar(\omega_p + \omega)$.

The deviation is

$$E_s - \bar{E}_s = E_s - \frac{E_T}{2} = \frac{E_T}{2} \frac{\sin \omega_p \Delta t}{\Delta t \omega_p}. \quad (74)$$

Further,

$$(E_s - \bar{E}_s)^2 = \frac{E_T^2 (\sin \omega_p \Delta t)^2}{4(\Delta t)^2 (\omega_p)^2}, \quad (75)$$

$$\overline{(E_s - \bar{E}_s)^2} = \frac{E_T^2}{4} \frac{1}{\Delta t^2 \omega_p^2} \doteq \frac{\hbar^2}{2\Delta t^2}, \quad (76)$$

$$\sqrt{\overline{(E_s - \bar{E}_s)^2}} \equiv \Delta E = \frac{\hbar}{\sqrt{2}\Delta t}. \quad (77)$$

From Eq. (77), we obtain the uncertainty relation

$$\Delta E \Delta t = \frac{\hbar}{\sqrt{2}}. \quad (78)$$

The energy is uncertain in measurement but conservative in $E_T = E_u + E_s$.

5. Universe Sphere Kinetics

5.1. Mechanical System of Universal Sphere

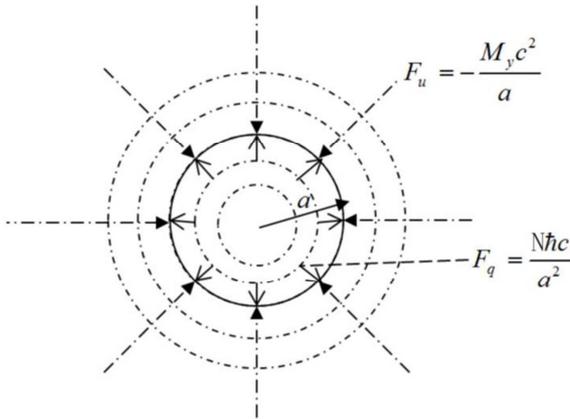


Figure 11. Universal sphere acted on by surface forces.

The “initial” universe is composed of vacuum plus excited state universal sphere as shown in Figure 11, of mass M_y , radius a . E_u is distributed in and out of the sphere. ρ_u is

$$F_T \equiv F_q + F_u = \frac{N \hbar c}{a^2} - \frac{M_y c^2}{a} = -M_y c^2 \left(\frac{a - a_0}{a^2} \right) \approx -M_y c^2 \left(\frac{a - a_0 - a_p}{a^2} \right). \tag{80}$$

Let $q_y = a_0[(a - a_0 - a_p)/a_0]$, where a_p is the universal sphere radius when stable vacuum is being formerly formed, $a_p \ll a_0$. In our study of the universe, we simply proceed from basic forces without using R-W metric and Einstein’s gravitational equations [13].

5.2. Equation of Motion

In the extraspherical flat coordinate system, time is not related to a and the equation of motion is

$$M_y a_0 \frac{d^2}{dt^2} \left(\frac{a - a_0 - a_p}{a_0} \right) = -M_y c^2 \left(\frac{a - a_0 - a_p}{a^2} \right). \tag{81}$$

In the intraspherical coordinate system, 3-D space is flat, time is related to a [14], $dt_a \equiv \frac{a_0}{a} dt$, the equation of motion is

$$M_y a_0 \frac{d^2}{dt_a^2} \left(\frac{a - a_0 - a_p}{a_0} \right) = -\frac{M_y c^2}{a_0} \left(\frac{a - a_0 - a_p}{a_0} \right) = -M_y \omega_y^2 (a - a_0 - a_p), \tag{82}$$

Where $\omega_y = \frac{c}{a_0}$.

The forces we are aware of in the universe sphere are

$$F_u^a = -\frac{M_y c^2}{a_0} \frac{(a - a_p)}{a_0} = -\frac{c^4}{G} \frac{(a - a_p)}{a_0}, \tag{83}$$

$$F_q^a = \frac{M_y c^2}{a_0} = \frac{c^4}{G} = \frac{G m_p^2}{r_p^2} = \frac{\hbar c}{r_p^2} = \frac{N \hbar c}{a_0^2}. \tag{84}$$

There are the similar basic actions in Einstein’s equations for the horizon [4].

The equation of motion can be simplified as

homogenously distributed inside the sphere while outside, $\rho_u = (GM_y m_p)/(4\pi r^4)$. E_s is homogenously distributed inside the universal sphere. $E_s = E_\phi + E_\sigma + E(a^*)$, E_ϕ is the (dark) energy of $N \phi$ field particles, E_σ is the (visible and invisible) energy of ordinary materials, while $E(a^*)$ is the expanded or contracted energy of the universal sphere as shown in figure 11.

As shown in figure 11, the interface exterior bears the universal compressive surface force $F_u = -M_y c^2/a$; while the interior of the interface bears the ϕ field quantum dispersive surface force $F_q = N \hbar c/a^2$.

When equilibrium,

$$\frac{N \hbar c}{a_0^2} = \frac{M_y c^2}{a_0}, \tag{79}$$

where a_0 is the radius of the universal sphere in equilibrium state. From Eq. (79) we can obtain $N \hbar c = M_y c^2 a_0$. For the P sphere vacuum equilibrium state there is $G m_p/r_p = c^2$. Similarly, for the universal sphere equilibrium state there is also $G M_y/a_0 = c^2$ that can lead to $G M_y = M_y c^2 a_0$. The total force borne by the universal sphere’s interface is

$$\frac{d^2}{dt_a^2} (a - a_0 - a_p) = -\omega_y^2 (a - a_0 - a_p). \tag{85}$$

Whose solution leads to

$$a = a_0 (1 - \cos \omega_y t_a) + a_p, \tag{86}$$

$$\frac{da}{dt_a} \equiv a^* = c \sin \omega_y t_a, \tag{87}$$

$$\frac{d^2 a}{dt_a^2} \equiv a^{**} = \omega_y^2 a_0 \cos \omega_y t_a = \frac{c^2}{a_0} \cos \omega_y t_a = -\omega_y^2 (a - a_0 - a_p). \tag{88}$$

Lagrangian function is

$$L_y = \frac{1}{2} M_y (q_y^*)^2 - \frac{1}{2} M_y \omega_y^2 q_y^2 - \frac{1}{2} M_y c^2. \tag{89}$$

5.3. Friedmann Equation

From equations (87) and (86) we have

$$(a^*)^2 = c^2 \left[1 - \left(\frac{a-a_0-a_p}{a_0} \right)^2 \right]. \quad (90)$$

Using $\dot{a} \equiv \frac{da}{dt}$, $\left(\frac{da}{dt} \right)^2 = (\dot{a})^2 \left(\frac{a}{a_0} \right)^2$, $\frac{GM_y}{a_0} = c^2$ and

$$\rho_s = \frac{M_y c^2}{\frac{4\pi}{3} a^3}, \quad (91)$$

Further we have

$$\frac{(a^*)^2}{c^2 a^2} + \frac{1}{a^2} = \frac{8\pi G}{3c^4} \rho_s \left[-\frac{a^3}{2a_0^3} + \frac{a^2 a_p}{a_0^3} - \frac{a a_p^2}{2a_0^3} + \frac{a^2}{a_0^2} - \frac{a a_p}{a_0^2} + \frac{a}{2a_0} \right], \quad (92)$$

$$\frac{(a^*)^2}{c^2 a^2} + \frac{1}{a^2} = \frac{8\pi G}{3c^4} \rho_s \left[1 + \frac{a_p}{a_0} - \frac{a_p}{a} \left(1 + \frac{a_p}{2a_0} \right) \right] \quad (93)$$

In the intraspherical coordinate system, when $a = a_0$ (equilibrium state), $a = 2a_0$ (static state),

$$\frac{(a^*)^2}{c^2 a^2} + \frac{1}{a^2} = \frac{8\pi G}{3c^4} \rho_s. \quad (94)$$

In the extraspherical coordinate system, when $a \gg a_p$,

$$\int_{a_p}^a \frac{M_y c^2}{a_0} da - \int_{a_p}^a \frac{M_y c^2}{a_0^2} (a - a_p) da = \frac{M_y c^2}{a_0} (a - a_p) - \frac{1}{2} \frac{M_y c^2}{a_0^2} (a - a_p)^2, \quad (100)$$

$$\frac{M_y c^2}{a_0} (a - a_p) = A_q(a_p \rightarrow a) = E_\phi(a_p) - E_\phi(a), \quad (101)$$

$$-\frac{1}{2} \frac{M_y c^2}{a_0^2} (a - a_p)^2 = A_u(a_p \rightarrow a) = E_\sigma(a_p) - E_\sigma(a). \quad (102)$$

Equation (98) becomes

$$\frac{1}{2} M_y [a^*(a)]^2 + E_\phi(a) + E_\sigma(a) = \frac{1}{2} M_y [a^*(a_p)]^2 + E_\phi(a_p) + E_\sigma(a_p). \quad (103)$$

$$Q=0.30, Q^2=0.09, a=0.3 a_0 \quad (108)$$

Obviously $a^*(a_p) = 0$, Letting $E_\phi(a_p) = M_y c^2$, $E_\sigma(a_p) = 0$, $Q \equiv \left(\frac{a-a_p}{a_0} \right)$, there will be the E_s conservation equation:

$$\frac{1}{2} M_y [a^*(a)]^2 + E_\phi(a) + E_\sigma(a) = M_y c^2 = E_{sT}, \quad (104)$$

where

$$E_\phi = M_y c^2 (1 - Q), \quad (105)$$

$$E_\sigma = M_y c^2 \frac{1}{2} Q^2, \quad (106)$$

$$E(a^*) = \frac{1}{2} M_y (a^*)^2 = M_y c^2 \left(Q - \frac{Q^2}{2} \right) \quad (107)$$

E_ϕ represents the so-called dark energy [33, 34], E_σ the energy of ordinary matter, $E(a^*)$ the kinetic energy for

$$\frac{(\dot{a})^2}{c^2 a^2} + \frac{1}{a^2} = \frac{8\pi G}{3c^4} \rho_s. \quad (95)$$

The Eq. (94) and Eq. (95) are Friedmann's equation [16, 17], which is simply a special example of Eq. (92) and (93), respectively. The Eq. (92) can be rewritten as E_u conservation equation:

$$\frac{1}{2} M_y (a^*)^2 + E_{up} = M_y c^2 = E_{uT}, \quad (96)$$

where

$$E_{up} = \left\{ M_y c^2 - \frac{GM_y^2}{a} \left[\left(\frac{a^2 - a a_p}{a_0^2} \right) + \left(-\frac{a^3}{2a_0^3} + \frac{a^2 a_p}{a_0^3} - \frac{a a_p^2}{2a_0^3} \right) \right] \right\}. \quad (97)$$

5.4. Dark Energy and Dark Matter

(1) The principle of the work-energy

Performing integration on the two sides of Eq. (82),

$$\int_{a_p}^a M_y \frac{d^2 a}{dt^2} da = \int_{a_p}^a \frac{M_y c^2}{a_0} da - \int_{a_p}^a \frac{M_y c^2}{a_0^2} (a - a_p) da, \quad (98)$$

$$\int_{a_p}^a M_y \frac{d^2 a}{dt^2} da = \frac{1}{2} M_y [a^*(a)]^2 - \frac{1}{2} M_y [a^*(a_p)]^2, \quad (99)$$

expanding (or contracting) motion of universe, or the so-called energy of "dark matter", E_{sT} total E_s .

(2) The proportions of all kinds of energies of current universe

If the percentage of the dark energy accounting for the total

energy $M_y c^2$ is $\frac{E_\phi}{E_T} = 1 - Q = 0.70$, then

$$\frac{E_\sigma}{E_T} = \frac{Q^2}{2} = 0.045, \quad (109)$$

$$\frac{E(a^*)}{E_T} = Q - \frac{Q^2}{2} = 0.255. \quad (110)$$

From $a = 0.3 a_0$, $a = a_0 (1 - \cos \omega_y t_a)$, $a^* =$

$c \sin \omega_y t_a$, $a^{**} = \frac{c^2}{a_0} \cos \omega_y t_a$, we have $a^* = 0.7c$, $a^{**} >$

0.

Our present-day universe: $a = 0.3a_0$, $a^* = 0.7c$, $a^{**} > 0$ (accelerated expansion); Dark energy accounts for 70%, ordinary matter accounts for 4.5%, “dark matter” accounts for 25.5%.

5.5. \mathcal{L}_y and \mathcal{L}_y

$$L_y = \frac{1}{2} M_y (a^*)^2 - (E_\phi + E_\sigma). \tag{111}$$

By making use of $Q \equiv \frac{a - a_p}{a_0}$, Eq. (105) and Eq. (106), we

have

$$L_y = \frac{1}{2} M_y c^2 \left(\frac{a_0^2}{c^2} (Q^*)^2 \right) - \frac{1}{2} M_y c^2 (Q^2 - 2Q + 1) - \frac{1}{2} M_y c^2, \tag{112}$$

where $Q^* \equiv \frac{d}{dt_a} Q$. Making use of $\frac{M_y c^2}{V} = \rho_s \approx \rho_u = \frac{c^4}{8\pi G} R$, we have

$$\mathcal{L}_y = \frac{-c^4}{16\pi G} R + \frac{c^4}{16\pi G} R \frac{a_0^2}{c^2} (Q^*)^2 - \frac{c^4}{16\pi G} R (Q^2 - 2Q + 1). \tag{113}$$

Letting $\Phi \equiv \frac{c^2}{\sqrt{G}} \left(\frac{a - a_0 - a_p}{a_0} \right) = \frac{c^2}{\sqrt{G}} (Q - 1) = \frac{\sqrt{\hbar c}}{r_p} (Q - 1)$ and $\Phi^* \equiv \frac{d}{dt_a} \Phi$, there will be

$$\mathcal{L}_y = \frac{-c^4}{16\pi G} R + \frac{a_0^2}{16\pi c^2} R (\Phi^*)^2 - \frac{1}{16\pi} R \Phi^2. \tag{114}$$

Letting $\phi \equiv \frac{c^2}{\sqrt{G}} \left(\frac{a - a_p}{a_0} \right) = \frac{c^2}{\sqrt{G}} Q = \frac{\sqrt{\hbar c}}{r_p} Q$ and $\phi^* \equiv \frac{d}{dt_a} \phi$, there will be

$$\mathcal{L}_y = \frac{-c^4}{8\pi G} R + \frac{a_0^2}{16\pi c^2} R (\phi^*)^2 - \frac{1}{16\pi} R \phi^2 + \frac{c^2}{8\pi\sqrt{G}} R \phi \tag{115}$$

Letting $\phi \equiv \frac{c^2}{\sqrt{G}} Q = \frac{\sqrt{\hbar c}}{r_p} Q$, $\sigma \equiv \frac{c^2}{\sqrt{G}} Q^2 = \frac{\sqrt{\hbar c}}{r_p} Q^2$, $\phi^* \equiv \frac{d}{dt_a} \phi$ and $\sigma^* \equiv \frac{d}{dt_a} \sigma$, results in

$$\mathcal{L}_y = \frac{-c^4}{8\pi G} R + \frac{a_0^2}{32\pi c^2} R (\phi^*)^2 + \frac{c^2}{8\pi\sqrt{G}} R \phi + \frac{a_0^2}{128\pi\sqrt{G}} R \frac{(\sigma^*)^2}{\sigma} - \frac{c^2}{16\pi\sqrt{G}} R \sigma \tag{116}$$

For lack of the one and only method of determining \mathcal{L} , people have given out many \mathcal{L}_y [18-22].

6. Conclusion

- (1) Both F_q and F_u that are duality basic actions in universe [8] dominate the oscillation of three sphere. For further details see the table 1.
- (2) The duality framework, has founded the fundamental equations of the gravitation, quantum and universe by the unified simple method; includes the whole framework of the modern fundamental physics and can solve the puzzlers about the singularity, non-locality, uncertainty of energy, et al.
- (3) The duality framework, can explain naturally many puzzlers of the quantum theory: the wave-particle duality, probabilistic nature, uncertainty of the energy and quantum entanglement; no using Einstein's theory, can obtain the mass- energy relation, Einstein's equations, Friedmann's equation, the acceleration of the universe expansion and the proportions of dark energy, “dark matter” and ordinary matter. The duality framework includes, links and foreruns both the

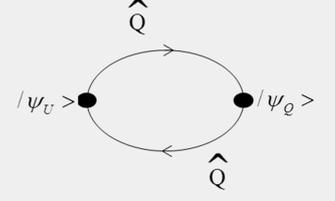
gravitation theory and the quantum theory, and is their common material foundation to give their unified harmonious image.

- (4) The E_u and E_s are transformed into each other at high frequency. The average effect of a long period is corresponding to U field and Q field. Space is the complex duality mechanical system of the U field and Q field. The excited U field and Q field simultaneously are two opposite faces of the particle. This opposite-unified entity is called the complex field and expressed as the direct product of U field and Q field. The gravitational field and its matching field are synchroquantized. This is our duality unity of gravitational field with other field. For further details see the table 2.
- (5) Daring predictions: The electromagnetic wave must have an adjoint strain wave. The gravitational wave must have an adjoint wave of matching field [35]. Because the energy of “dark matter” is the kinetic energy for expanding (or contracting) motion of universe, it is in the wrong direction to find the particle of the “dark matter” [36-43].

Table 1. Three sphere oscillation.

Mechanical system	P sphere	C sphere	Y sphere
Equilibrium state	$\frac{m_p c^2}{r_p} = \frac{\hbar c}{r_p^2}$ $r_p = \frac{\hbar}{m_p c}$	$\frac{m c^2}{r_c} = \frac{\hbar c}{r_c^2}$ $r_c = \frac{\hbar}{m c}$	$\frac{M_y c^2}{a_0} = \frac{N \hbar c}{a_0^2}$ $a_0 = \frac{N \hbar}{M_y c} = \frac{G M_y}{c^2}$
Generalized coordinate	$q_p \equiv r_p \Sigma_p \equiv r_p \left[\frac{E_u - E_s}{E_p} \right]$	$q_c \equiv r_c \Sigma_c \equiv r_c \frac{\psi}{ \psi_V }$	$q_y \equiv a_0 \Sigma_y \equiv a_0 \left[\frac{a - a_0 - a_p}{a_0} \right]$
Generalized action	$F_p = -\frac{m c^2}{r_p} + \frac{\hbar c}{r_p^2} \frac{m_s}{m_p} \equiv -\frac{G m_p^2}{r_p^2} \left[\frac{E_u - E_s}{E_p} \right]$	$F_c = -\frac{G m_p^2}{r_c^2} \frac{\psi}{ \psi_V }$	$F_y = -\frac{M_y c^2}{a} + \frac{N \hbar c}{a^2} = -\frac{G M_y^2}{a_0^2} \left[\frac{a - a_0 - a_p}{a^2} \right] a_0$
L	$L_p = \frac{1}{2} m_p \dot{q}_p^2 - \frac{1}{2} m_p \omega_p^2 q_p^2$	$L_c = \frac{1}{2} m \dot{q}_c^2 - \frac{1}{2} m \omega^2 \bar{q}_c q_c$	$L_y = \frac{1}{2} M_y (q_y^*)^2 - \frac{1}{2} M_y \omega_y^2 q_y^2 - \frac{1}{2} M_y c^2$
Equation of motion	$m_p r_p \frac{d^2}{d\tau^2} \left[\frac{E_u - E_s}{E_p} \right] = -\frac{G m_p^2}{r_p^2} \left[\frac{E_u - E_s}{E_p} \right]$ $\frac{d^2}{d\tau^2} \left[\frac{E_u - E_s}{E_p} \right] = -\omega_p^2 \left[\frac{E_u - E_s}{E_p} \right]$ $E_u = \frac{E_T}{2} (1 - \cos \omega_p \tau)$ $E_s = \frac{E_T}{2} (1 + \cos \omega_p \tau)$ oscillation of $E_u \leftrightarrow E_s$	$m r_c \frac{d^2}{d\tau^2} \left[\frac{\psi}{ \psi_V } \right] = -\frac{G m_p^2}{r_c^2} \left[\frac{\psi}{ \psi_V } \right]$ $\frac{d^2}{d\tau^2} \psi = -\omega^2 \psi$ $\psi = \psi(\bar{r}) e^{-i\omega\tau}$ Oscillation of ψ effect	$M_y a_0 \frac{d^2}{dt^2} \left[\frac{a - a_0 - a_p}{a_0} \right] = -\frac{G M_y^2}{a_0^2} \left[\frac{a - a_0 - a_p}{a_0} \right]$ $\frac{d^2}{dt^2} \left[\frac{a - a_0 - a_p}{a_0} \right] = -\omega_y^2 \left[\frac{a - a_0 - a_p}{a_0} \right]$ $a = a_0 (1 - \cos \omega_y t_a) + a_p$ Oscillation of curvature effect of Y sphere

Table 2. The complex field.

	The U field	The complex field	The Q field
$E_u \leftrightarrow E_s$ oscillation	$E_u = \frac{E_T}{2} (1 - \cos \omega_p \tau)$, $\bar{E}_u = \frac{E_T}{2}$	$m_p r_p \frac{d^2}{d\tau^2} \left(\frac{E_u - E_s}{E_p} \right) = -\frac{G m_p^2}{r_p^2} \left(\frac{E_u - E_s}{E_p} \right)$	$E_s = \frac{E_T}{2} (1 + \cos \omega_p \tau)$, $\bar{E}_s = \frac{E_T}{2}$
Vacuum state	$ o\rangle_U$	$ o\rangle \equiv o\rangle_U \otimes o\rangle_Q$	$ o\rangle_Q$
Operator	\hat{g}^+ , \hat{g}	$\hat{A}^+ \equiv \hat{g}^+ \otimes \hat{a}^+$, $\hat{A} \equiv \hat{g} \otimes \hat{a}$	\hat{a}^+ , \hat{a}
State vector	$\hat{g}^+ o\rangle_U = 1\rangle_U$ $\hat{g} 1\rangle_U = 0\rangle_U$ $\hat{g} 0\rangle_U = 0$	$(\hat{g}^+ \otimes \hat{a}^+) (o\rangle_U \otimes o\rangle_Q) = \hat{g}^+ o\rangle_U \otimes \hat{a}^+ o\rangle_Q$ $\hat{A}^+ o\rangle \equiv 1\rangle_U \otimes 1\rangle_Q = 1\rangle$ $\hat{A} 1\rangle \equiv 0\rangle$ $\hat{Q} \equiv \hat{g}^+ \otimes \hat{a} + \hat{a}^+ \otimes \hat{g}$	$\hat{a}^+ o\rangle_Q = 1\rangle_Q$ $\hat{a} 1\rangle_Q = 0\rangle_Q$ $\hat{a} 0\rangle_Q = 0$
Mutual transformation of states	$ \psi_U\rangle \equiv 1\rangle_U \otimes 0\rangle_Q$ $\hat{Q} \psi_U\rangle = \psi_Q\rangle$ $\hat{Q} \hat{Q} \psi_U\rangle = \psi_U\rangle$		$ \psi_Q\rangle \equiv 0\rangle_U \otimes 1\rangle_Q$ $\hat{Q} \psi_Q\rangle = \psi_U\rangle$ $\hat{Q} \hat{Q} \psi_Q\rangle = \psi_Q\rangle$
Equation of energy eigenvalues	$\hat{H}_U = \hbar \omega (\hat{g}^+ \hat{g} + \frac{1}{2})$ $\hat{H}_U 1\rangle_U = (\hbar \omega + \frac{1}{2} \hbar \omega) 1\rangle_U$	$\hat{H}_U + \hat{H}_Q$ $(\hat{H}_U + \hat{H}_Q) 1\rangle \equiv [(\hbar \omega + \frac{1}{2} \hbar \omega)_U + (\hbar \omega + \frac{1}{2} \hbar \omega)_Q] 1\rangle$	$\hat{H}_Q = \hbar \omega (\hat{a}^+ \hat{a} + \frac{1}{2})$ $\hat{H}_Q 1\rangle_Q = (\hbar \omega + \frac{1}{2} \hbar \omega) 1\rangle_Q$

(Cambridge University Press and Peking University Press, 2013), P. 466, 474, 673.

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