Is the State of Low Energy Stable? Negative Mass, Dark Energy and Dark Matter

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Abstract. All this time, the field of physics did not seriously consider the possibility of existence of negative mass (energy) in a general state. [1–4] The standard explanation of negative mass is that the state of low energy is stable when a negative energy level exists and that the lowest state of energy is minus infinity. Thus, this means that all positive mass emits energy and it will be transitioned to the energy level of minus infinity and the universe will collapse. [5] However, at the present, our universe exists without collapsing, so the explanation for this has become strong proof of the nonexistence of the negative mass and negative energy level of. Thus, we have considered this to be obvious common sense and have taught this to students. At the center of this background, there is the fundamental principle (proposition) that "State of low energy is stable" [2] [6] In this article, we will reveal that this principle is an incomplete, and that it is stable at a low energy state in the case of positive mass. However, it is stable at a high energy state in the case of negative mass. [7] [8] Due to this, "the problem of the transition of the energy level of minus infinity" does not occur, and the existence of negative mass is therefore possible. Moreover, we will show that negative mass provides an explanation for dark matter and dark energy, which are the biggest issues posed to cosmology at the present. We demonstrate the 'ratio of matter : dark matter : dark energy' through this model, and computer simulation shows that this assumption is appropriate.

Keyword : negative energy, negative mass, dark energy, dark matter, gravitational potential energy, antigravity, cosmological constant, cosmology, zero energy universe

I. A Stable State and Negative Energy

1. A Stable State and a Low Energy State

Water flows downwards from the top and a ball also rolls down from the hills towards the flatlands. Empirically, we know from our daily experiences that a lower place is stable and that an object moves toward a lower place.

In case of conservative force in physics, we know that affixing a $-$ mark to the gradient of potential energy is the direction of force.

$$\vec{F} = m\vec{a} = -\vec{\nabla}U \tag{1}$$

Dynamically, a stable state can be defined as a state of motility in which net force is zero or force, although its applied, is not beyond a certain range.

We know that in simple harmonic oscillation, which is a simple model of dynamics, positive mass receives force while moving toward a minimum point and, at this minimum point, harmonic oscillation occurs. In this manner, positive mass is stable at a lower energy state. [6]

Therefore, a stable state and a lower energy state had been regarded as an identical idea, became a very important and fundamental proposition in physics and became regarded as common sense which was unquestioned.

But, I've never asked such a question like this.

Where does nature move towards a stable state or a lower energy state?

2. Total Energy Equation of Special Relativity

From $E = mc^2$, we know that mass and energy are equivalent.

Therefore, negative energy has negative mass.

$$m = \frac{E}{c^2} \tag{2}$$

In addition, we obtained another important result− a relativistic total energy formula.

$$E^2 = (m_0c^2)^2 + (pc)^2 \tag{3}$$

We know that the above formula has two solutions.

$$\begin{aligned} E_+ &= +\sqrt{(m_0c^2)^2 + (pc)^2} \\ E_- &= -\sqrt{(m_0c^2)^2 + (pc)^2} \end{aligned} \tag{4}$$

However, we determined that total energy could not exist at a negative state and abandoned the solution of negative energy. Only the great physicist, Dirac was able to connect a solution of negative energy to antimatter. [9] But, despite how Dirac reached his discovery on antimatter, antimatter still has positive energy. In other words, it is less likely that antimatter is the true owner of a negative energy solution.

3. An Important Study on Negative Mass

In 1957, Professor Hermann Bondi examined the characteristics of the negative mass from the perspective of General Relativity [10] and, after this, Robert L. Forward looked into a propulsion method using negative mass. [11]

Nevertheless, even to this day, we are pessimistic about the existence of negative mass and do not consider it seriously. In the fundamental background of this problem, there is the reason of not having observed the negative mass, but also not resolving the "the problem of the transition of the energy level of minus infinity" ultimately.

Until the present, when explaining relativistic total energy in a Classical Mechanics class or explaining Dirac's positron and antimatter in a Modern Physics or Elementary Particle Physics classes, we explain "the problem of the transition of the energy level of minus infinity" with the proposition “the state of low energy is stable” and consequently taught that negative mass and negative energy do not exist in our universe

4. Negative Mass Is Stable at the State of High Energy. [7] [8]

If negative mass exists, is it stable at a lower energy state?

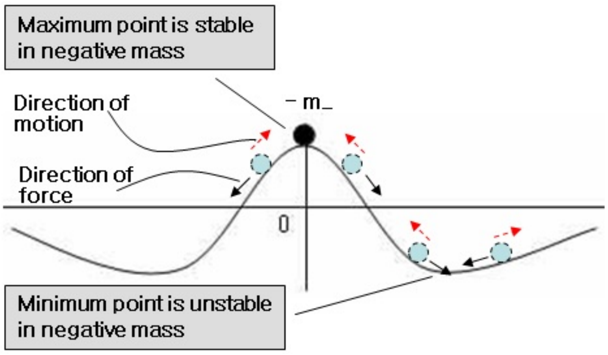


Figure 1: When there is negative mass in potential which has a point of maximum value and a point of minimum value.

$$\vec{F} = -m_- \vec{a} \quad (m_- > 0) \tag{5}$$

$$\vec{a} = -\frac{\vec{F}}{m_-} \tag{6}$$

The acceleration of negative mass is opposite to the direction of force. Therefore, the negative mass has harmonic oscillation at the maximum point and it is also stable at the maximum point.

In the case of positive mass, it was stable at the minimum point at which energy is the low. However, in case of negative mass, stable equilibrium is a point of maximum value, not a point of minimum value.

5. The Transition from Positive Energy Levels to Negative Energy Levels

In case of a positive mass, it could have negative energy level within negative potential. Nevertheless, even in this case, the total energy containing potential energy was still in the state of positive energy.

However, for positive mass to enter the domain of (total energy is negative) negative energy level, energy should have negative value, and this means that it should have the characteristics of negative mass.

When considering the process of entering into the domain of negative energy levels from positive energy levels, it must pass through the domain between 0^- (Approach from negative direction to ‘0’) and $-\frac{1}{2}\hbar\omega$ (corresponds to a certain negative energy level). In the case that it follows the laws of negative mass because it is in the domain of negative energy, it cannot reach $-\frac{1}{2}\hbar\omega$, which is the first negative energy level, because it is stable at the state of high energy and it tries to have higher value of energy.

This is because the energy level 0^- is much higher than the energy level $-\frac{1}{2}\hbar\omega$. Thus, this implies that the law of negative mass itself does not allow a situation where positive mass at the positive energy level transitions to the negative energy level.

Even if it reaches $-\frac{1}{2}\hbar\omega$, it is most stable state for negative mass and "the problem of the transition of the energy level of minus infinity" does not occer.

As we have examined above, "the problem of the transition of the energy level of minus infinity" does not occur, and thus positive mass and negative mass can exist in the same space-time. This is a very important result because it means that negative mass and negative energy can exist stably in our universe.

II. The Motion of Negative Mass and the Reason for Nonobservance of Negative Mass

1. The Movement of Negative Mass [8]

Negative mass has repulsive gravitational effect each other. Due to the limitation in length of this article, a video was made for you to reference.

[Computer simulation] : time 0m.10s – 2m.40s [12]

2. Why Has Negative Mass Been Unobserved All Along?

1) The problem of nonobservance within the Earth and our galaxy

If negative mass and positive mass were came into being together at the beginning of universe, since positive mass has attractive effects with each other, so it forms stars and galaxy. In addition, negative mass has repulsive effects towards each other so it cannot form any structure and may spread out almost uniformly across the whole area of universe.

Owing to the effect of negative mass and positive mass, negative mass disappears near massive positive mass structures (such as the galaxy and galaxy clusters, etc.) after meeting positive mass. However, negative mass, which came into existence at the beginning of universe, can still exist in a vacuum state outside of general galaxy.

The current structure of the galaxy is a structure that survived in the pair-annihilation of positive mass and negative mass and, since negative mass existed outside of this galaxy structure, therefore it has not been observed.

2) The problem of nonobservance outside our galaxy

Negative mass has repulsive gravitational effect towards each other so it cannot make massive mass structures like stars or galaxies. Therefore, it has not been observed even through observation of the universe until now.

III. Utilization of Negative Mass (Energy)

1. Initial Energy Value of the Universe [8]

In regards to the initial value of the energy of the universe, it is a little more natural when an initial energy value of universe is 0. Therefore, negative energy is needed to offset the positive energy of matter.

$$E_T = 0 = (+E) + (-E) = (\sum m_+ c^2) + (\sum -m_- c^2) + (\sum U) = 0 \quad (7)$$

2. Problem of Infinity Mass Density in the Early Universe

The current big bang model is problematic in that our universe is expanding from the state of going beyond the density of black hole in the early universe.

If negative mass and positive mass came into existence together at the beginning of universe, even though all the mass of the universe comes together in one small area during the Big Bang, it does not have the density as the black hole due to the offsetting of density by positive mass and negative mass. Therefore, it is expandable.

[Computer simulation] : time 9m.15s – 14m.11s [12]

3. Too Large Vacuum Energy Value

The vacuum energy value which is currently known is an energy value that is too big($10^{111} J/m^3$). [13] If this vacuum energy exists, it is difficult to explain why it is not easily found around us.

In the model of the pair creation of negative mass and positive mass, vacuum energy will become exactly 0 because vacuum is the space in which pair creation and pair annihilation of positive and negative energy occurs.

4. Flatness Problem

Positive energy and negative energy are cancelled in a zero energy universe. So, this explains the universe being almost flat.

5. Dark Energy [8] [14]

ΛCDM −our current standard model of cosmology− is successful in overall, but neither Λ or CDM has been successfully proven. [15–17] In my opinion, at this point, what we can trust is the information that a certain repulsive gravitational (accelerating expansion) effect and an attractive gravitational (centripetal force) effect exists in the universe.

At the present, it is understood that dark matter and dark energy are completely different in nature. Dark matter corresponds to an attractive effect, whereas dark energy corresponds to a repulsive effect. Therefore, dark matter and dark energy have a completely different significance.

However, if negative mass (energy) exists, it is possible to explain the dark matter and the dark energy at the same time.

1) Result of the field equation

In 1998, an observation by both the HSS team and SCP team obtained a negative mass density from inspected field equations (non cosmological constant eq.) over 70years.

HSS(The High-z Supernova Search) team : If $\Lambda = 0$, $\Omega_M = -0.38(\pm 0.22)$ [3]

SCP(Supernova Cosmology Project) team : If $\Lambda = 0$, $\Omega_M = -0.4(\pm 0.1)$ [4]

However, the two teams which judged that negative mass and negative energy level could not exist in our universe based on "the problem of the transition of the energy level of minus infinity" and they instead revised the field equation by inserting the cosmological constant.

Moreover, we considered vacuum energy as the source of cosmological constant Λ, but the current result of calculation shows difference of 10^{120} times, which is unprecedented even in the history of Physics. [15]

However, if "the problem of the transition of the energy level of minus infinity" does not occur and thus negative and positive mass can coexist, what would happen?

It is well known that a cosmological constant can respond to the negative mass density. $\rho_{eff} = -\frac{\Lambda}{4\pi G}$, Λ is positive, so ρ_{eff} is negative.

2) We judge the components of the universe by gravitational effect rather than mass energy

If negative mass and positive mass coexist, gravitational potential energy (GPE) consists of the following three items.

$$U_T = U_{-+} + U_{--} + U_{++} \tag{8}$$

$$U_T = \sum_{i,j}\left(-\frac{G(-m_{-i})m_{+j}}{r_{-+ij}}\right) + \sum_{i<j}\left(-\frac{G(-m_{-i})(-m_{-j})}{r_{--ij}}\right) + \sum_{i<j}\left(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}\right) \tag{9}$$

$$U_T = \sum_{i,j}\left(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}\right) + \sum_{i<j}\left(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}\right) + \sum_{i<j}\left(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}\right) \tag{10}$$

When the number of negative mass is n_-, and the number of positive mass is n_+, the total potential energy is given as follows.

$$U_T = (n_- \times n_+)U_{-+} + \left(\frac{n_-(n_- - 1)}{2}U_{--} + \frac{n_+(n_+ - 1)}{2}U_{++}\right) \tag{11}$$

For example, when two pairs exist,

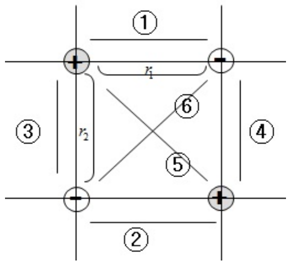


Figure 2: When two pair exist

$$\begin{aligned} U_T &= (U_1 + U_2 + U_3 + U_4) + U_5 + U_6 \\ &= (4U_{-+}) + 1U_{++} + 1U_{--} \end{aligned} \tag{12}$$

GPE shows important characteristics **when negative mass and positive mass both exist. While n^2 positive (repulsive) gravitational potential terms are produced, $n^2 - n$ negative (attractive) gravitational potential terms are also produced.** Therefore, the total GPE can have various values $(-, 0, +)$.

$$E = T + V = \frac{1}{2}mv^2 - \frac{GMm}{r} = const.$$

$$\frac{1}{2}mH^2r^2 - \frac{G\frac{4\pi}{3}r^3\rho m}{r} = -\frac{1}{2}mkc^2\overline{w}^2$$

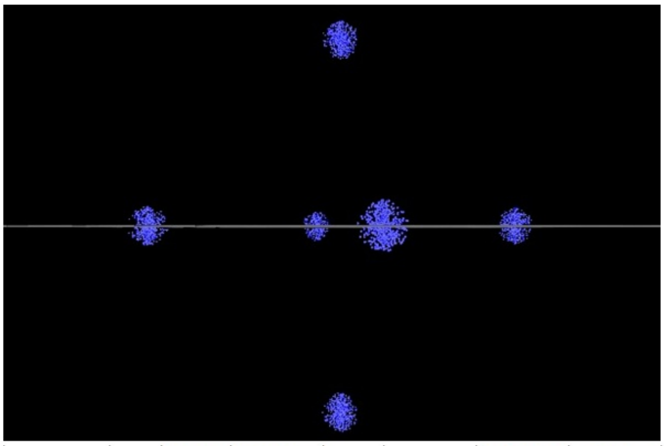
$$\left[\left(\frac{\dot{a}}{a}\right)^2 - \frac{8\pi G\rho}{3}\right] = \frac{-kc^2}{a^2}$$

Figure 3: From the Friedmann equation, we judge the components of the universe by gravitational effect (or GPE) rather than mass energy.

The acoustic oscillation model which played a key role in determining the composition of the universe is based on the equation for force and force is associated with potential energy.

Therefore, **when gravitational potential energy U_{-+} is larger than gravitational potential energy U which is generated by materials, we can estimate that some mass energy bigger than the mass energy of materials exists.**

As a matter of fact, through numerical calculation using a computer, the distribution having a similar value to the predicted rate of WMAP was revealed.



		WMAP	Ratio
Matter	U++	4.6	1
Dark Matter	U--	23.3	5.065
Dark Energy	U-+	72.1	15.674
Ratio +/-			2.584

	Simulation	Ratio
U++	- 83.2	1
U--	- 459.6	5.523
U-+	1286.9	15.463
Ratio +/-		2.371

Figure 4: $m_+ = +100$ X $6 = +\ 600$. $(\pm1200,0,0)$, $(0,\pm1200,0)$, $(0,0,\pm1200)$, each 100. $-m_- = (-0.2$ X $500)$ X $6 = -600$. Negative mass distribution : center1,2($\pm$1200,0,0), center3,4(0,$\pm$1200,0), center5,6(0,0,$\pm$1200), negative mass is spread within R=3 $\sim$120, min. distance = 8. [14]

Through the distribution of a negative mass and a positive mass when total mass energy is at the state of '0',(see to figure 4) we could obtain a similar result to WMAP observation or predicted ratio. [18] This suggests that the currently predicted energy ratio comes from the distribution that negative masses are surrounding the galaxy or the galaxy clusters.

Matter = U_{++} =−83.2 (ratio: 1)

Dark Matter = U_{--} =−459.6 (ratio: 5.523)

Dark Energy = U_{-+} =+1286.9 (ratio : +15.463) : repulsive gravitational effect

It is similar the ratio of matter(4.6% : 1):dark matter(23.3% : 5.06):dark energy(72.1% : +15.67 : repulsive gravitational effect).

Through the distribution of a negative mass and a positive mass when total mass energy is at the state of 0, we could obtain a similar result to WMAP observation or predicted ratio.

This does not mean that 72.1% of dark energy exists independently, but it means that the explanation of GPE (U_{-+}) occurring from negative energy, which is the same as positive energy, is possible. Moreover, this negative energy is the energy which is inevitably required from zero energy, which is the most natural total energy value in the universe.

In other words, if the repulsive GPE which is 15 times more than the GPE created by an object exists without the need for dark energy 15 times more than the mass energy of an object, this may be able to explain about the effect of dark energy.

Surprisingly, this means that 15 times more repulsive gravitational effect is possible at the state of zero energy.(see to figure 4.)

6. Dark Matter [8]

Negative mass of the external galaxy can incur additional effects within the inner galaxy such as centripetal force.

1) Centripetal force effect

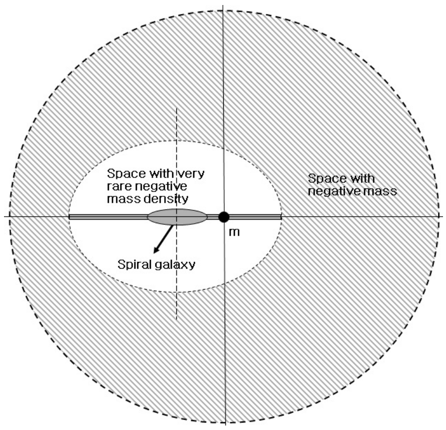


Figure 5: The structure of the galaxy surrounded by negative mass that is distributed equally. Negative mass is surrounding the galaxy that consists of positive mass. The white area is the area where negative mass almost does not exist.

Let's examine the effect of the centripetal force of negative mass that is outside the galaxy on mass m, which is located within the galaxy.

a. If we assume that the white empty space is full of negative mass and positive mass at the same density,

White empty space = 0 = $(+mc^2) + (-mc^2) = 0$

b. Negative mass is now uniformly distributed over the whole area so the effect of negative mass on mass m becomes 0.

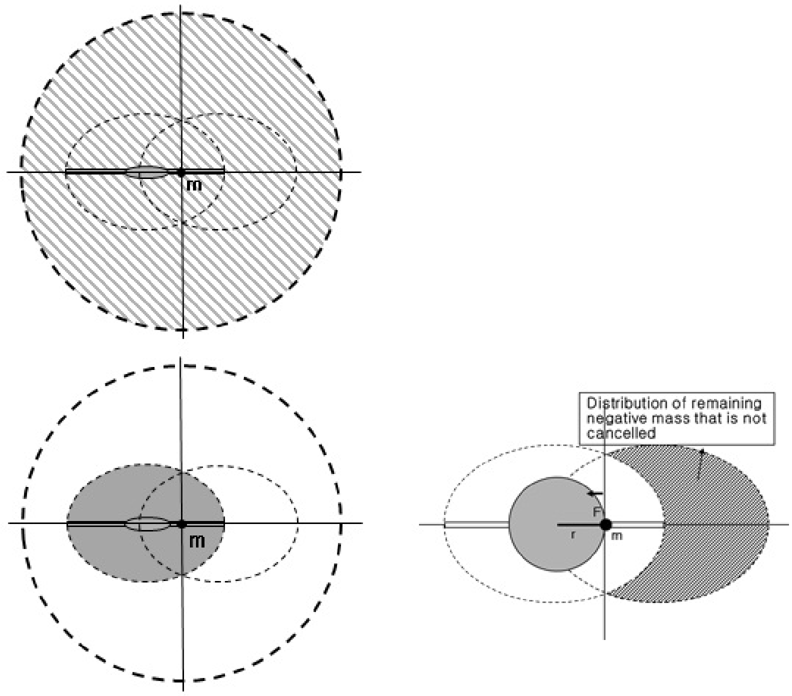


Figure 6: The effect of negative mass that remains outside of the galaxy can make it possible to be approximate to the gravity generated by the distribution of positive mass within the radius r in the galaxy.

c. The remaining positive mass is distributed over the white area at the density of negative mass, and the gravity that uniformly distributes positive mass works on positive mass m located on radius r is worked upon only by the distribution of mass within radius r. - Shell Theorem.

Therefore, the effect of negative mass that remains outside of the galaxy can make it possible to be approximate to the gravity generated by the distribution of positive mass within the radius r in the galaxy.

This means that the dark matter, consisting of negative mass outside galaxy, has additional effect of centripetal force on stars within the galaxy.

This effect suggests that the further from the center of the galaxy, the more mass effect exists and agrees with the current situation where the further from the center of the galaxy, the more dark matter exists.

The analysis above was conducted under the assumption that the distribution of negative mass outside the galaxy is in a uniform form. However, the galaxy actually consists of positive mass that affects gravitationally negative mass outside the galaxy so the density of negative mass outside the galaxy is not uniform.

2) The problem of nonobservance of galaxy or cluster of galaxies consisted of dark matter

The repulsive gravity effect among dark matter(negative mass) makes difficult for galaxy or clusters of galaxies, which are only consisted of dark matter, to form massive mass structure.

3) [Computer simulation] : time 6m.00 – 7m.50s [12]
If the negative mass is disposed at the outline, the test mass vibrates. Therefore a kind of centripetal force exists. Please view to simulation video.

7. New Field Equation and Friedmann Equation
Einstein's field equation :

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G T_{\mu\nu} \tag{13}$$

We need making new Friedmann eq. and field eq., on the assumption that negative energy(mass) and positive energy(mass) coexist.

If negative energy and positive energy coexist, GPE consists of the below three terms.
$U_T = U_{++} + U_{--} + U_{-+}$
$= \sum_{i>j} -\frac{Gm_{+i}m_{+j}}{r_{++ij}} + \sum_{i>j} -\frac{Gm_{-i}m_{-j}}{r_{--ij}} + \sum_{i,j} +\frac{Gm_{-i}m_{+j}}{r_{-+ij}}$

Matter (Positive mass) : $\sum_{i>j} -\frac{Gm_{+i}m_{+j}}{r_{++ij}} \rightarrow 8\pi G({}^{++}T_{\mu\nu})$
Dark Matter (Negative mass) : $\sum_{i>j} -\frac{Gm_{-i}m_{-j}}{r_{--ij}} \rightarrow 8\pi G({}^{--}T_{\mu\nu})$
Dark Energy (GPE between negative mass and positive mass) : $\sum_{i,j} +\frac{Gm_{-i}m_{+j}}{r_{-+ij}} \rightarrow 8\pi G({}^{-+}T_{\mu\nu})$

Therefore, new field equation is

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G({}^{++}T_{\mu\nu} + {}^{--}T_{\mu\nu} + {}^{-+}T_{\mu\nu}) \tag{14}$$

At this time, we should considering the structure that negative mass surrounds galaxy or galaxy cluster composed of positive mass.

Only the positive mass world, the Earth and the Solar system

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G({}^{++}T_{\mu\nu}) \tag{15}$$

Thus, we get an Einstein's field eq.

But negative energy(mass) existed outside of this galaxy structure, So, we observe the dark matter term and dark energy term in the universe.

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G({}^{++}T_{\mu\nu} + {}^{--}T_{\mu\nu} + {}^{-+}T_{\mu\nu}) \tag{16}$$

We need solve this new field eq.

The existing physical world uses a temporary solution or does a trick to account for accelerating expansion. They introduce $+\rho_\Lambda$ corresponding to positive mass in relation to dark energy to avoid negative mass as source of gravitation. However, this cannot produce accelerating expansion effect. So we introduce the pressure which is three times more than $+\rho_\Lambda$

that corresponds to the mass energy of dark energy itself, and the density of negative mass is shifted to this pressure. ("negative pressure" is introduced).

Pressure is expressed like $P = -\rho_\Lambda c^2$. Thus, the term related to dark energy in the right side of field equation is

$$\rho_\Lambda + \frac{3P_\Lambda}{c^2} = \rho_\Lambda + \frac{3(-\rho_\Lambda c^2)}{c^2} = -2\rho_\Lambda \tag{17}$$

Finally, the result is that the energy that had negative values existed from the beginning.

From the beginning, **the accelerating expansion of the universe meant that there existed 'density of negative energy' in the right side of field equation. This suggests that if it's moved to the left side, there exists 'positive GPE'.**

Friedmann equation utilized dynamic energy conservation applied into positive mass. This is the equation of motion in the universe that is composed of 'one kind' of gravitational characteristic.

However, if there exists two kinds of gravitational sources, GPE is composed of three terms. U_{11}(GPE between type 1s)+ U_{22}(GPE between type 2s)+ U_{12} (GPE between type 1 and type 2)

When positive mass(energy) and negative mass(energy) exist together, the universe has the following formula.

$$E = T + V = \sum \frac{1}{2} m_{+i} {v_{+i}}^2 + \sum (-\frac{1}{2} m_{-j} {v_{-j}}^2) + \sum U_{++} + \sum U_{--} + \sum U_{-+} = const. \tag{18}$$

$(m_+ > 0, m_- > 0)$

In the first place, if we look at the term that includes positive mass that attracts our attention,

$$E = \sum \frac{1}{2} m_{+i} {v_{+i}}^2 + \sum_{i<j} (-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i,j} (+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}) \tag{19}$$

It's like this. Herein, as $\sum_{i,j}(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}})$ has positive values, it has a repulsive gravitation (antigravity) effect. Therefore, it corresponds to Λ, that of dark energy that accelerates the current universe.

Changes in the existing dynamic energy conservation formula: I am not sure about the followings, but it is supposed that there will be changes as follows.

$\frac{1}{2}mv^2(t) - \frac{GM_+m}{r(t)} = -\frac{1}{2}mkc^2\varpi^2$ ->

$$\frac{1}{2}mv^2(t) - \frac{GM_+m}{r(t)} + k_h(t)\frac{GM_+m}{r(t)} = +\frac{1}{2}mkc^2\varpi^2 \tag{20}$$

$[(\frac{1}{R}\frac{dR}{dt})^2 - \frac{8\pi G\rho}{3} - \frac{1}{3}\Lambda c^2]R^2 = -kc^2$ ->

$$\left[\left(\frac{1}{R}\frac{dR}{dt}\right)^2 - \frac{8\pi G\rho}{3} + \frac{1}{3}\Lambda(t)c^2\right]R^2 = +kc^2 \tag{21}$$

We cannot conclude that this model is wrong although this model is different from the values of the existing ΛCDM model. All results from the ΛCDM model are consistent within the system. The universe that consists of two gravitational sources differs from their movement. Thus, we need to set up new Friedmann equations and field equations to solve problems.

Nevertheless, this model provides similar results to ΛCDM model, because 'U_{-+}(repulsive GPE)' and 'U_{--}(attractive GPE)' that will play a role as Λ and CDM are added one by one.

Therefore, we need to make new Friedmann equations and field equations appropriate for this model to reorganize the total and compare two models.

8. Demonstration of Constituent Ratio of the Universe

1) Theoretical demonstration of constituent ratio of the universe

A. Total GPE in the universe that consists of negative mass and positive mass, and dark energy

Let's find values at the easiest state when matters are evenly distributed and then expand them into the state that shows the current universe.

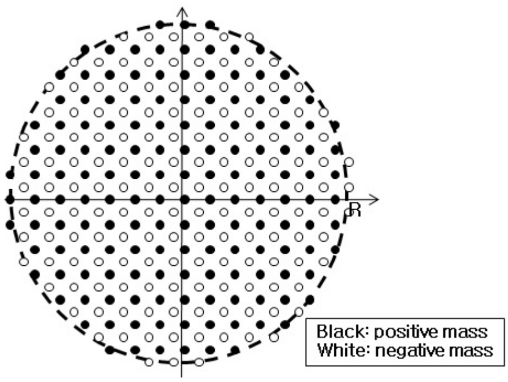


Figure 7: Universe where negative mass(energy) and positive mass(energy) are evenly distributed

Total GPE U_T is as shown in equation (10). As we maintain that each GPE corresponds to matter, dark matter, and dark energy, the following formula can be drawn.

$$U_T = \sum_{i<j}\left(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}\right) + \sum_{i<j}\left(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}\right) + \sum_{i,j}\left(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}\right) \quad (22)$$

$$= U_m + U_d + U_\Lambda \quad (23)$$

$(m_+ \geq 0, m_- \geq 0)$

The concept of gravitational self-energy which consists of two types of positive mass corresponds to the state that all GPE terms have negative values.

$$U_S = \sum_{i<j}\left(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}\right) + \sum_{i<j}\left(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}\right) + \sum_{i,j}\left(-\frac{Gm_{-i}m_{+j}}{r_{-+ij}}\right) \quad (24)$$

$$= U_m + U_d - U_\Lambda \quad (25)$$

$$= -\frac{3}{5}\frac{GM^2}{R} \quad (26)$$

Let's consider that any GPE terms that constitute the system do not disappear when finding U_T or U_S.

$$U_m + U_d - U_\Lambda = -\frac{3}{5}\frac{G{M_+}^2}{R} - \frac{3}{5}\frac{G{M_-}^2}{R} - U_\Lambda = -\frac{3}{5}\frac{GM^2}{R} \tag{27}$$

$(M_+ = M_- \geq 0, M = M_+ + M_-)$
As positive masses are evenly distributed in radius R, $U_m = -\frac{3}{5}\frac{G{M_+}^2}{R}$
As negative masses are evenly distributed in radius R, $U_d = -\frac{3}{5}\frac{G{M_-}^2}{R}$
Therefore, it can be inferred that the dark energy itself will have the following forms.

$$U_\Lambda = +k_h(t)\frac{GM^2}{R} \tag{28}$$

In the above, a simple case that positive mass and negative mass are evenly distributed was assumed, but in our real universe, the distribution of positive mass and negative mass are varied. For this reason, coefficient $k_h(t)$ was introduced.

We can find the current $k_h(t)$ values in observing the universe.

Planck satellite's result - matter : dark matter : dark energy = 4.9% : 26.8% : 68.3% [19]

$$\frac{U_m + U_d}{U_\Lambda} = -b_{Planck} = \frac{(-4.9) + (-26.8)}{68.3} \simeq -0.464 \tag{29}$$

From the equation (25), (26)

$$(-b-1)U_\Lambda = -\frac{3}{5}\frac{GM^2}{R} \tag{30}$$

$$U_\Lambda \approx \frac{1}{(1+b)}\frac{3}{5}\frac{G(2M_+)^2}{R} = (2.73)\frac{3}{5}\frac{G{M_+}^2}{R} = +k_h(t)\frac{G{M_+}^2}{R} \tag{31}$$

[8]

Planck's $k_h(t_0) = 1.638$, WMAP's $k_h(t_0) = 1.728$ [18]

B. If positive mass(energy) and negative mass(energy) are completely evenly distributed

$$U_m = U_d = -\frac{3}{5}\frac{G{M_+}^2}{R} = -\frac{3}{5}\frac{G{M_-}^2}{R} \tag{32}$$

$$U_m + U_d - U_\Lambda = -\frac{3}{5}\frac{G{M_+}^2}{R} - \frac{3}{5}\frac{G{M_-}^2}{R} - U_\Lambda = -\frac{3}{5}\frac{GM^2}{R} \tag{33}$$

$$U_\Lambda = \frac{3}{5}\frac{G(2M_+)^2}{R} - \frac{3}{5}\frac{G{M_+}^2}{R} - \frac{3}{5}\frac{G{M_+}^2}{R} = (-2)\times(-\frac{3}{5}\frac{G{M_+}^2}{R}) = -2U_m \tag{34}$$

Therefore, total GPE is

$$U_T = U_{++} + U_{--} + U_{-+} = U_m + U_d + U_\Lambda = 0 \tag{35}$$

Thus, matter(positive mass), dark matter(negative mass), dark energy(GPE between positive mass and negative mass) are

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -1 : -1 : +2 = 25\% : 25\% : 50\% \quad (36)$$

We need to be careful for this. The above ratio is not the ratio of mass energy but that of GPE, and the expansion of the universe in this model is determined by GPE.

In the earlier paper, [14] I showed that the universe was expanding even in the state when total GPE is 0, that is, a complete zero energy state, through computer simulation. This is because GPE that determines the motion of positive mass is not 0 although total GPE is 0.

From the above (19) and (22) equation,

$$\sum_{i<j}\left(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}\right) + \sum_{i,j}\left(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}\right) = U_m + U_\Lambda \quad (37)$$

There are two GPE terms that include positive mass. This is because the sum of these is not 0.

C. Current universe: unless positive mass and negative mass are evenly distributed in all scales

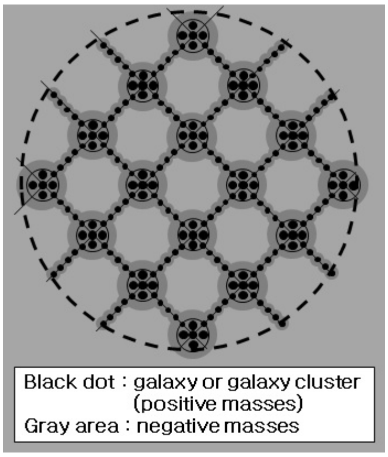


Figure 8: The current universe presumed in this model: Although the positive mass(black dot) constitute galaxy or cluster of galaxies and negative mass(gray) are almost evenly distributed in the entire universe, it is presumed that the density of negative mass(dark gray) near the galaxy would be higher than that of negative mass in the void area(gray), because negative mass receives attractive gravitational effect from large positive mass. [8], [12]

C-1)If positive mass constitutes galaxy or cluster of galaxies and negative mass are completely distributed evenly

$U_{++} = -\frac{3}{5}\frac{G{M_+}^2}{R}$ needs to be corrected because its not that positive mass is completely distributed evenly.

Let's get a hint from the movement between the sun and the earth!

Total GPE between the sun and the earth is

$U_T = U_s =$ Sun's gravitational self-energy + Earth's gravitational self-energy + GPE between the sun and the earth

$$U_T = U_S = U_{self-Sun} + U_{self-Earth} + U_{Sun-Earth} \quad (38)$$

$$U_{Sun-Earth} = U_S - (U_{self-Sun} + U_{self-Earth}) \quad (39)$$

However, the particles that constitute the sun always move together because they are strongly bond gravitationally. Likewise, the particles that constitute the earth always move together because they are strongly bond gravitationally. Therefore, what determines the movement between the sun and the earth is the only 'GPE between the sun and the earth'.

In other words, the GPE of objects that are strongly bond gravitationally does not change. It means that the GPE of objects that are strongly bond gravitationally does not contribute to the movement of other objects.

We can see that galaxies or cluster of galaxies are strongly bond gravitationally. Thus, we should subtract these GPE terms.

$$U_{++} = U_m = -\frac{3}{5}\frac{G{M_+}^2}{R} - N(-\frac{3}{5}\frac{G{m_+}^2}{r_0}) = -\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] \quad (40)$$

*M_+ : (Probably) Total mass of matters within Hubble's radius or the visible universe

*R : (Probably) Hubble's radius or the visible universe's radius

*m_+ : Average mass of objects strongly bond gravitationally (Probably, mass of galaxies or cluster of galaxies)

*r_0 : Average radius of objects strongly bond gravitationally

*N : Number of objects strongly bond gravitationally

*$M_+ = M_-$, $M = M_+ + M_-$

On the other hand, negative mass has gravitation effect which is repulsive each other. Accordingly, if we assume that the entire universe is almost evenly distributed,

$$U_{--} = U_d = -\frac{3}{5}\frac{G{M_-}^2}{R} = -\frac{3}{5}\frac{G{M_+}^2}{R} \quad (41)$$

$$\frac{U_{--}}{U_{++}} = \frac{U_d}{U_m} = \frac{-\frac{3}{5}\frac{G{M_-}^2}{R}}{-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = \frac{1}{1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}} = c \quad (42)$$

$$N(\frac{m_+}{M_+})^2\frac{R}{r_0} = 1 - \frac{1}{c} \quad (43)$$

$$N(\frac{{\rho_{m+}}^2{r_0}^5}{{\rho_{M+}}^2R^5}) = 1 - \frac{1}{c} \quad (44)$$

$c_{WMAP} = \frac{23.3}{4.6} \simeq 5.065$, $c_{Planck} = \frac{26.8}{4.9} \simeq 5.469$

Now, let's find dark energy.

If $U_S \approx -\frac{3}{5}\frac{GM^2}{R}$,

From the equation (25),

$$-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - \frac{3}{5}\frac{G{M_-}^2}{R} - U_\Lambda \approx -\frac{3}{5}\frac{GM^2}{R} \quad (45)$$

$$U_\Lambda \approx +\frac{3}{5}\frac{GM^2}{R} - \frac{3}{5}\frac{GM_+{}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - \frac{3}{5}\frac{GM_-{}^2}{R} \tag{46}$$

i) WMAP

$$U_\Lambda \approx +\frac{3}{5}\frac{G(2M_-)^2}{R} - \frac{3}{5}\frac{GM_-{}^2}{R}(\frac{1}{5.065}) - \frac{3}{5}\frac{GM_-{}^2}{R} \tag{47}$$

$$= +\frac{3}{5}\frac{GM_-{}^2}{R}(4 - \frac{1}{5.065} - 1) = (-2.803)U_d \tag{48}$$

Therefore,

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.197 : -1 : +2.803 = 4.93\% : 25.00\% : 70.07\% \tag{49}$$

It's very close to WMAP value.
ii) Planck

$$U_\Lambda \approx +\frac{3}{5}\frac{G(2M_-)^2}{R} - \frac{3}{5}\frac{GM_-{}^2}{R}(\frac{1}{5.469}) - \frac{3}{5}\frac{GM_-{}^2}{R} \tag{50}$$

$$\approx -\frac{3}{5}\frac{GM_-{}^2}{R}(-2.817) = (-2.817)U_{--} \tag{51}$$

Therefore,

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.183 : -1 : +2.817 = 4.58\% : 25.00\% : 70.43\% \tag{52}$$

Also, it's similar to the estimation data of Planck satellite. Therefore, this model has potential.

C-2) If positive mass constitutes galaxy or cluster of galaxies and negative mass is close to the structure surrounding the cluster of galaxies

From the motional characteristics of negative mass and positive mass, great positive mass gives attractive effect to the individual negative mass. [8] [12] Therefore, negative mass exists with higher density near the galaxies or cluster of galaxies that constitute positive mass. (Refer to figure 8.)

$$U_{++} = U_m = -\frac{3}{5}\frac{GM_+{}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] \tag{53}$$

In classical mechanics, the fact that GPE is given as follows can be found through calculation, in case of mass distribution that $0 \sim r_0$ are empty and $r_0 \sim r_1$ are occupied.

$$U_S = -\frac{G(4\pi\rho)^2}{3}\left[\frac{1}{5}r_1{}^5 - \frac{r_0{}^3}{2}r_1{}^2 + \frac{3}{10}r_0{}^5\right] \tag{54}$$

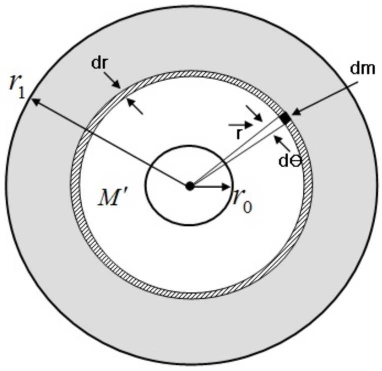


Figure 9: $0 \sim r_0$: positive mass distribution, $r_0 \sim r_1$: negative mass distribution

However, part of the negative mass are evenly distributed in the entire universe like figure8, and some are distributed near the cluster of galaxies that constitute positive mass.

$$M_- = m_{-u} + Nm_- \tag{55}$$

*m_{-u} : Constituents that are evenly distributed in the entire universe
*Nm_- : Constituents near the cluster of galaxies that constitutes positive mass

$$U_{--} = U_d = \sum_{i<j} (-\frac{Gm_{-i}m_{-j}}{r_{--ij}}) = -\frac{3}{5}\frac{GM_-{}^2}{R} - N(-\frac{G(4\pi\rho_-)^2}{3}\left[\frac{1}{5}r_1{}^5 - \frac{r_0{}^3}{2}r_1{}^2 + \frac{3}{10}r_0{}^5\right]) \tag{56}$$

$$U_{--} = -\frac{3}{5}\frac{GM_-{}^2}{R}\left[1 - \frac{5NR(4\pi\rho_-)^2}{9M_-{}^2}\left[\frac{1}{5}r_1{}^5 - \frac{r_0{}^3}{2}r_1{}^2 + \frac{3}{10}r_0{}^5\right]\right] \tag{57}$$

$$\frac{U_{--}}{U_{++}} = c = \frac{-\frac{3}{5}\frac{GM_-{}^2}{R}\left[1 - \frac{5NR(4\pi\rho_-)^2}{9M_-{}^2}\left[\frac{1}{5}r_1{}^5 - \frac{r_0{}^3}{2}r_1{}^2 + \frac{3}{10}r_0{}^5\right]\right]}{-\frac{3}{5}\frac{GM_+{}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} \tag{58}$$

$$c = \frac{1 - \frac{5NR(4\pi\rho_-)^2}{9M_-{}^2}\left[\frac{1}{5}r_1{}^5 - \frac{r_0{}^3}{2}r_1{}^2 + \frac{3}{10}r_0{}^5\right]}{\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} \tag{59}$$

Currently, U_{--} and U_{-+} are has complex shape. So it's not organized nicely. This leaves us the next research problems. At this point in time, we want to prove the possibility of this model based on what's observed.

C-2)-1) If $U_S \approx -\frac{3}{5}\frac{GM^2}{R}$

$$\begin{aligned}
U_\Lambda &\approx \frac{3}{5}\frac{GM^2}{R} + U_m + U_d && (60)\\
&= \frac{3}{5}\frac{GM_+{}^2}{R}\left(4 - \left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - c\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]\right) && (61)\\
&= \frac{3}{5}\frac{GM_+{}^2}{R}\left((3-c) + (1+c)N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right) && (62)
\end{aligned}$$

$$\frac{U_\Lambda}{U_{++}} = \frac{\left[(3-c)+(1+c)N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]}{\left[1-N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = d \tag{63}$$

We define $N(\frac{m_+}{M_+})^2\frac{R}{r_0} = \chi_h$,

$$\frac{[(3-c)+(1+c)\chi_h]}{(1-\chi_h)} = d \tag{64}$$

$$\chi_h = \frac{c+d-3}{c+d+1} \tag{65}$$

i) WMAP

$$\chi_{hW} = \frac{c+d-3}{c+d+1} \simeq \frac{5.065+15.673-3}{5.065+15.673+1} = 0.816 \tag{66}$$

$$U_m \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.184] \tag{67}$$

$$U_d \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.932] \tag{68}$$

$$U_\Lambda \approx +\frac{3}{5}\frac{G{M_+}^2}{R}[2.884] \tag{69}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.184 : -0.932 : +2.884 = 4.6\% : 23.3\% : 72.1\% \tag{70}$$

ii) Planck

$$\chi_{hP} = \frac{c+d-3}{c+d+1} \simeq \frac{5.469+13.938-3}{5.469+13.938+1} = 0.804 \tag{71}$$

$$U_m \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.196] \tag{72}$$

$$U_d \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[1.071] \tag{73}$$

$$U_\Lambda \approx +\frac{3}{5}\frac{G{M_+}^2}{R}[2.733] \tag{74}$$

It's reasonable to assume that the upper limit of coefficient U_d is 1. The below is the value when the upper limit of coefficient U_d is corrected as 1.

$$U_m \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.183] \tag{75}$$

$$U_d \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[1.000] \tag{76}$$

$$U_\Lambda \approx +\frac{3}{5}\frac{G{M_+}^2}{R}[2.549] \tag{77}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.183 : -1 : +2.549 = 4.9\% : 26.8\% : 68.3\% \tag{78}$$

C-2)-2) If $U_\Lambda \approx (-2)(-\frac{3}{5}\frac{G{M_+}^2}{R})$

This value(eq.(34)) is the value of dark energy obtained when positive mass(energy) and negative mass(energy) are evenly distributed in 8-1)-B.

As it is seen that the universe transforms locally from uniform state to un-uniform one, coefficient (-2) plays a role like lower limit. It's because U_Λ tends to increase if positive mass and negative mass are gravitationally shrunk in local area. [14]

$$U_\Lambda = (-2)(-\frac{3}{5}\frac{G{M_+}^2}{R}) \rightarrow (-2.884)(-\frac{3}{5}\frac{G{M_+}^2}{R})$$

$$\frac{U_\Lambda}{U_{++}} = \frac{-\frac{3}{5}\frac{G{M_+}^2}{R} \times (-2)}{-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = \frac{-2}{\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = d \tag{79}$$

$$N(\frac{m_+}{M_+})^2\frac{R}{r_0} = 1 + \frac{2}{d} \tag{80}$$

i) WMAP

$$\chi_{hW} = 1 + \frac{2}{d} \simeq 1 + \frac{2}{-15.673} = 0.872 \tag{81}$$

$$U_m \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.128] \tag{82}$$

$$U_d \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.648] \tag{83}$$

$$U_\Lambda \approx +\frac{3}{5}\frac{G{M_+}^2}{R}[2.000] \tag{84}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.128 : -0.648 : +2.000 = 4.6\% : 23.3\% : 72.1\% \tag{85}$$

ii) Planck

$$\chi_{hP} = 1 + \frac{2}{d} \simeq 1 + \frac{2}{-13.938} = 0.857 \tag{86}$$

$$U_m \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.143] \tag{87}$$

$$U_d \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.782] \tag{88}$$

$$U_\Lambda \approx +\frac{3}{5}\frac{G{M_+}^2}{R}[2.000] \tag{89}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.143 : -0.782 : +2.000 = 4.9\% : 26.8\% : 68.3\% \quad (90)$$

D. Entire change
Uniformly distribution –> locally un-uniform distribution

D-1) Uniformly distribution

$$U_{++} = U_m = -\frac{3}{5}\frac{G{M_+}^2}{R}[1] \quad (91)$$

$$U_{--} = U_d = -\frac{3}{5}\frac{G{M_+}^2}{R}[1] \quad (92)$$

$$U_{-+} = U_\Lambda = +\frac{3}{5}\frac{G{M_+}^2}{R}[2] \quad (93)$$

$$U_T = U_{++} + U_{--} + U_{-+} = U_m + U_d + U_\Lambda = 0 \quad (94)$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -1 : -1 : +2 = 25\% : 25\% : 50\% \quad (95)$$

D-2) Locally un-uniform distribution
i) WMAP

$$U_{++} = U_m \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.128 \sim 0.184] \quad (96)$$

$$U_{--} = U_d \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.648 \sim 0.932] \quad (97)$$

$$U_{-+} = U_\Lambda \approx +\frac{3}{5}\frac{G{M_+}^2}{R}[2.000 \sim 2.884] \quad (98)$$

$$U_T = U_{++} + U_{--} + U_{-+} = U_m + U_d + U_\Lambda > 0 \quad (99)$$

ii) Planck

$$U_{++} = U_m \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.143 \sim 0.183] \quad (100)$$

$$U_{--} = U_d \approx -\frac{3}{5}\frac{G{M_+}^2}{R}[0.782 \sim 1.000] \quad (101)$$

$$U_{-+} = U_\Lambda \approx +\frac{3}{5}\frac{G{M_+}^2}{R}[2.000 \sim 2.549] \quad (102)$$

$$U_T = U_{++} + U_{--} + U_{-+} = U_m + U_d + U_\Lambda > 0 \quad (103)$$

We can answer the CCC problem of "Why does dark energy have the similar scale with matters?". It is because it has the same gravitational effect as them.

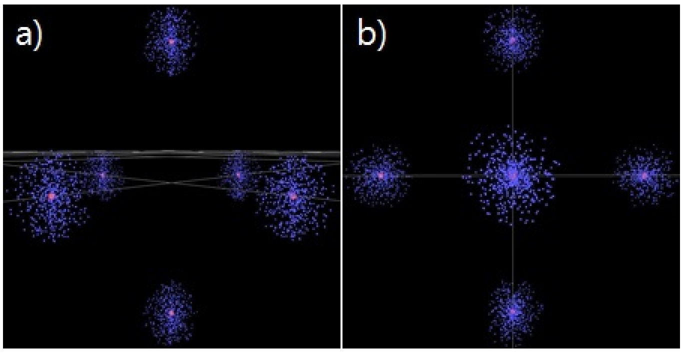


Figure 10: Distribution of six galaxies: Initial state distribution: $m_+ = +100$ X $6 = +600$. Center1,2($\pm$100,0,0), center3,4(0,$\pm$100,0), center5,6(0,0,$\pm$100), each 100. $-m_- =$(-0.2 X 500) X 6 $=-600$. Negative mass distribution : center1,2($\pm$100,0,0), center3,4,(0,$\pm$100,0), center5,6(0,0,$\pm$100), negative mass is spread within $R = 3 \sim 120$, min. distance = 8. Center1 $\sim$ 6 are increased by 1000 so that each of them can correspond to the expansion of the universe(100,1100,2100,...,9100). In other words, the changes in GPE are observed by changing the distance between six galaxies.

2) Computer simulation of matter : dark matter : dark energy ratio depending on the expansion of the universe

The above experiment shows the state that the cluster of galaxies that constitute positive mass surrounded by the negative mass. The experiment aims to look at which characteristics appear when the universe is expanding according to Hubble's law. It is supposed that as the changes in the structure of galaxy are very slow even in the process that the universe is expanding, the shape of galaxies is maintained.

R	100	Ratio	1100	Now	2100	Ratio	3100	Ratio	4100	Ratio
U++	-998.53	-1.00	-90.78	-1.00	-47.55	-1.00	-32.21	-1.00	-24.35	-1.00
U--	-1333.99	-1.34	-473.15	-5.21	-424.61	-8.93	-410.63	-12.75	-402.08	-16.51
U-+	3101.93	3.11	1319.36	14.53	1212.93	25.51	1191.85	37.00	1170.89	48.08
U_tot	769.41		755.44		740.77		749.01		744.46	
+GPE/-GPE	1.33		2.34		2.57		2.69		2.75	
R	5100	Ratio	6100	Ratio	7100	Ratio	8100	Ratio	9100	Ratio
U++	-19.58	-1.00	-16.37	-1.00	-14.06	-1.00	-12.33	-1.00	-10.97	-1.00
U--	-394.28	-20.14	-391.77	-23.93	-393.06	-27.95	-389.54	-31.60	-388.53	-35.41
U-+	1157.14	59.10	1147.28	70.09	1146.86	81.55	1143.88	92.79	1144.55	104.31
U_tot	743.27		739.14		739.74		742.01		745.05	
+GPE/-GPE	2.80		2.81		2.82		2.85		2.86	

Figure 11: Uniquely, there are changes in the ratio of U_{++}, U_{--}, and U_{-+} when the distance between galaxies drifts farther. Such results appear evident in particular when positive mass combine gravitationally and galaxies are treated as a single gravitational object.

A. Surprisingly, the ratio of U_{++}, U_{--}, and U_{-+} changes simply when the universe expands according to Hubble's law.

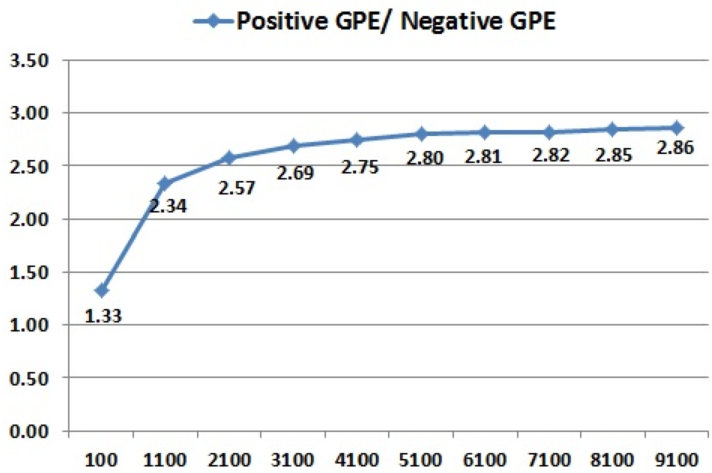


Figure 12: The change of the ratio of +GPE to −GPE by changing the distance between six galaxies.

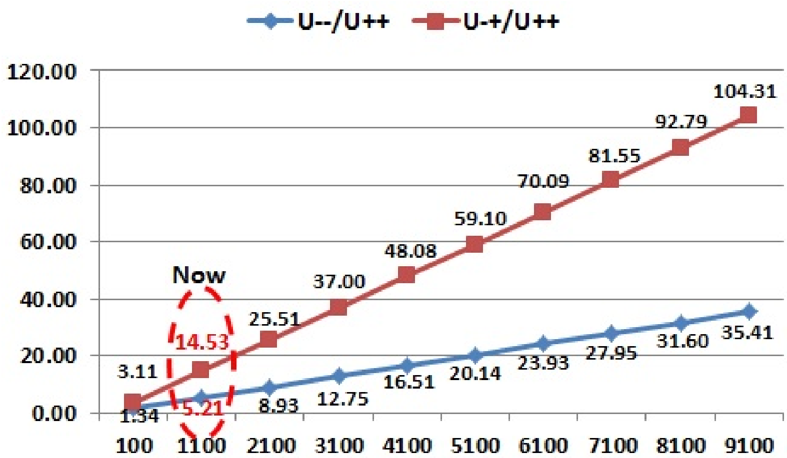


Figure 13: U_{--}/U_{++} and U_{-+}/U_{++}

B. This experiment suggests that the ratio (repulsive GPE)/(attractive GPE) can increase only under the fact that the universe is expanding. This is similar to the fact that dark energy increases as the universe expands. $U_{-+}=$ repulsive GPE, $|U_{++}+U_{--}|=$ attractive GPE.

C. If we suppose Hubble expansion only, ratio of (repulsive GPE)/(attractive GPE) has a possibility of converting to a particular value.

D. ΛCDM model expects that the ratio of matters and dark matters will be constant, but this model suggests that as the universe expands, the gravitation effect of matters vs dark matters differs. Finally, in the current mainstream physical description, we will describe that the amount of dark matters gradually increases. Therefore, the past and the future predicted by two models are different.

We must not throw away the other models without reviews even if the ΛCDM model is right overall. It's because if ΛCDM model is right, the model has to account for Λ and CDM as completely as possible, but they are not successful now.

The reason why the entire explanation of ΛCDM at this point in time seems to be right is that the repulsive gravitation effect corresponding to Λ and the attractive gravitational effect are required. However, this can be explained by this model(Pair creation of positive energy and negative energy) and adding to this, negative mass(energy) is the object that satisfies energy conservation and the object which is inevitably required from the law of energy conservation.

References

[1] David Halliday and Robert Resnick. *Fundamentals of Physics.* Second ed.(John Wiley & Sons, Inc., Hoboken , 1987).

[2] R. Eisberg and R. Resnick. *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles.* Second ed.(John Wiley & Sons, Inc., Hoboken , 1993).

[3] Riess, A. G. et al. Observational evidence from supernovae for an accelerating universe and a cosmological constant. Astron. J. 116, 10091038 (1998).

[4] Perlmutter, S. et al. Measurements of omega and lambda from 42 high-redshift supernovae. Astrophys. J. 517, 565586 (1999).

[5] Michio Kaku. *Physics of the Impossible.*(Stuart Krichevsky Literary Agency, New York, 2008).

[6] Marion. *Classical Dynamics of Particles and Systems.* (Univ. of MARYLAND, Maryland, 1993).

[7] Hyoyoung Choi. Study of Interaction between Negative mass and Positive mass. (Konkuk University Press, Seoul,1997).

[8] Hyoyoung Choi. Hypothesis of Dark Matter and Dark Energy with Negative Mass. (2009). [http://vixra.org/abs/0907.0015].

[9] Dirac, Paul A. M.. Theory of Electrons and Positrons. The Nobel Foundation. (1993) `http://nobelprize.org/nobel_prizes/physics/laureates/1933/dirac-lecture.html`.

[10] H. Bondi. Negative Mass in General Relativity. Rev. Mod. Phys. 29 No. 3 July (1957).

[11] Robert L. Forward. Negative Matter Propulsion. J.Propulsion.Vol. 6, No.1,(1990).

[12] Hyoyoung Choi. Is the Low Energy State Stable? Negatiove Mass And Negative Energy.(2012)[http://www.youtube.com/watch?v=MZtS7cBMIc4].

[13] Bradley W. Carroll, Dale A. Ostlie. Introduction to Modern Astrophysics. 2nd Edition. (Pearson Education, Inc.,Upper Saddle River, 2007)

[14] Hyoyoung Choi. The Change of Gravitational Potential Energy And Dark Energy in the Zero Energy Universe, (2011). [http://vixra.org/abs/1110.0019]

[15] Sean Carroll. The cosmological constant. Living Reviews in Relativity.(2001) `http://relativity.livingreviews.org/Articles/lrr-2001-1/`.

[16] The XENON100 Collaboration. Implications on Inelastic Dark Matter from 100 Live Days of XENON100 Data. (2011). [arXiv:1104.3121v1][arXiv:1104.3121v1].

[17] CDMS Collaboration. Results from a Low-Energy Analysis of the CDMS II Germanium Data. Phys.Rev.Lett.106:131302,(2011).

[18] E. Komatsu et al. Seven-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation. Astrophys.J.Suppl.192:18,(2011).

[19] Planck Collaboration. Planck 2013 results. XVI. Cosmological parameters. (2013). [arXiv:1303.5076][arXiv:1303.5076].

Supplementary Information

Original version of this article was submitted at FQXi essay contest(2012. http://fqxi.org/community/forum). And I do improve it.