Pair Creation Model of The Universe From Positive and Negative Energy

Hyoyoung Choi ∗
Prabir Rudra †

∗*Department of Physics, Konkuk University, Hwayang-dong, Gwangjin-gu, Seoul, Korea.*
[7icarus7@gmail.com]

†*Department of Mathematics, Bengal Engineering and Science University, Shibpur, Howrah-711 103, India.*
Department of Mathematics, Pailan College of Management and Technology, Kolkata-700104
[prudra.math@gmail.com]

Abstract

Departing from the abstract aversion of the concept of negative mass (energy), we propose a pair creation model of the universe taking into account the possibility of co-existence of both positive and negative mass particles. Nature of negative mass has been given a fair thought and the possible dynamics is studied. The existence of negative mass has been theoretically justified. The birth of the universe is explained and the future is predicted using the pair creation model. Various cosmological problems have been discussed and it has been shown that the model presents an obvious solution to all of them. Einstein's field equations of General Relativity have been modified in the light of the model. The energy ratio of the components of the universe (matter, dark matter and dark energy) is studied using the model and found to be comparable with the experimental data obtained from WMAP and Planck. Finally it is concluded that the model deserves a serious consideration, given its consistency with the observational data.

1 Introduction

Till date the possibility of the existence of negative mass(energy) in a general state have not been given a fair thought by physicists.[1] The basic reason behind this is that, since all positive masses emit energy (thus moving towards a lower energy state), a transit to the energy level of minus infinity will see the universe collapse.[2][3] However, at present our universe exists without collapsing, thus totally ruling out the possibility of the existence of negative mass and negative energy. Standing on this, we have framed the fundamental principle that **"State of low energy is stable"**, since the transition to minus infinity energy level is not a problem for positive (or normal) mass. What if the truth is completely opposite for negative mass! What if the stable state for negative mass is the high energy state! In that case the problem of transition to minus infinity energy level is not an issue and therefore the existence of negative mass is justified.

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 relatively lower place is stable and that an object moves toward a lower place. According to basic level physics, this lowers the gravitational potential energy of the body, thus bringing about a transition to a relatively stable state.

In case of conservative force in Physics, we know that affixing a − mark to the gradient of potential energy gives 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. 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.[4]

Therefore, a stable state and a lower energy state have been considered as identical ideas, one implying the other. Since this directly follows from intuition, the idea remain unquestioned, thus becoming a very important and fundamental principle in Physics. But, Have we ever considered such questions as:

Does all the constituents of nature really move towards a lower energy state while attaining a stable configuration?
Does the behavior of all the constituents of nature resemble that of positive mass?

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

Therefore, common sense says that negative energy must have 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 speculated that total energy could not exist at a negative state and abandoned the solution of negative energy, and just as a mere convention accepted the positive solution without much reasoning. It was only through the hands of Dirac, that negative energy gained some status in a society that is totally pessimistic about the concept. He was able to connect a solution of negative energy to antimatter [2]. But the path that Dirac followed to reach his discovery on antimatter, revealed that antimatter has positive energy. In other words, it is less likely that antimatter is truly responsible for the negative energy solution.

In 1957, Professor Hermann Bondi examined the characteristics of the negative mass from the perspective of General Relativity[5] and, after this, Robert L. Forward looked into a propulsion method using negative mass.[6]

Nevertheless, even to this day, we are pessimistic about the existence of negative mass and do not consider it seriously. The two-fold reasons behind this being the non-observability of negative mass and the problem of transition to minus infinity energy level as the final fate of the universe. As a result, till date we have based our physics on the two basic assumptions of "the state of low energy is stable" and "negative mass and negative energy do not exist in our universe".

The motivation behind the present study is that the possibility of the existence of negative mass will provide an effective and simple solution to the present Dark energy (DE)[7, 8, 9, 10, 11] and Dark matter (DM) problem[12, 13, 14] in Cosmology without resorting to the far reaching complications of General Relativity (GR). The justification towards the accelerated expansion in the late universe may not be so complicated as it shapes out to be in modern cosmology. **After all both the concepts of Dark energy and Modified gravity are totally theoretical, without much observational evidence. As a result the concepts are just in their verification level. If we can accept them just on the basis of theoretical consistency, why not Negative energy!!** Every phenomenon of nature, in its early stages of detection seems to be crooked and difficult until it is studied properly. Experience simplifies the problem and finally we are confronted with simple laws of nature, which seems to be obvious from our intuition. Therefore there is no harm in considering that cosmology is currently in its stage infancy. Knowledge of human beings in the field of cosmology might just be at the elementary level lacking proper logical reasoning. The concept of Negative energy can just be the light in the darkness as far as modern cosmology is concerned.

2 Some Basic Proposals about Negative Mass and Negative Energy

2.1 Extended Newton's law of motion

2.1.1 The motion of negative mass and positive mass

$$-m_1\vec{a}_1 = -G\frac{(-m_1)m_2}{r^2}\hat{r} \tag{5}$$

$$\vec{a}_1 = -G\frac{m_2}{r^2}\hat{r} \tag{6}$$

Figure 1: Negative mass -m_1 and positive mass +m_2 (initial velocity =0, $m_1 > 0$, $m_2 > 0$)

$$+m_2\vec{a}_2 = -G\frac{m_2(-m_1)}{r^2}\hat{r} \tag{7}$$

$$\vec{a}_2 = G\frac{m_1}{r^2}\hat{r} \tag{8}$$

Negative mass and positive mass : Negative mass is accelerated in the direction of positive mass, and positive mass is accelerated in the direction to be far away from negative mass.

The direction of acceleration a1 worked on negative mass $-m_1$ is $-\hat{r}$, so $-m_1$ moves in the direction of reducing distance r, and the direction of acceleration $\vec{a}_2$ worked on positive mass $+m_2$ is $+\hat{r}$, so positive mass $+m_2$ is accelerated in the direction that distance r increases, namely the direction of being far away from negative mass.

As we can see in the equation above, the term of acceleration remains only because mass m_1 is erased from both terms. Now the equation of motion means the equation of acceleration, not the equation of force, the acceleration provides information of motion direction, and decides the direction of motion.

If the absolute value of positive mass is bigger than that of negative mass, they will meet within finite time(attractive effect), and if the absolute value of positive mass is smaller than that of negative mass, the distance between them will be bigger, and they cannot meet(repulsive effect). The type of force is repulsion, so the potential energy has positive value.

This property is very important. Negative masses are gravitational bounded to massive positive masses (Galaxy or cluster of galaxies) for massive positive mass has attractive effect on negative mass.

2.1.2 The motion of negative mass and negative mass

Figure 2: Negative mass -m_1 and negative mass -m_2 (initial velocity =0, $m_1 > 0$, $m_2 > 0$)

$$-m_1\vec{a}_1 = -G\frac{(-m_1)(-m_2)}{r^2}\hat{r} \tag{9}$$

$$\vec{a}_1 = +G\frac{m_2}{r^2}\hat{r} \tag{10}$$

$$-m_2\vec{a}_2 = -G\frac{(-m_2)(-m_1)}{r^2}\hat{r} \tag{11}$$

$$\vec{a}_2 = +G\frac{m_1}{r^2}\hat{r} \tag{12}$$

Negative mass and negative mass: Both two objects are accelerated in the direction of $+\hat{r}$ which extends distance r, so as time passes, the distance between them is greater than initially given condition, and the force between them is attraction, but the effect is repulsive. The force is attraction($-Gm_1m_2/r^2$), thus the potential energy between them has negative value.

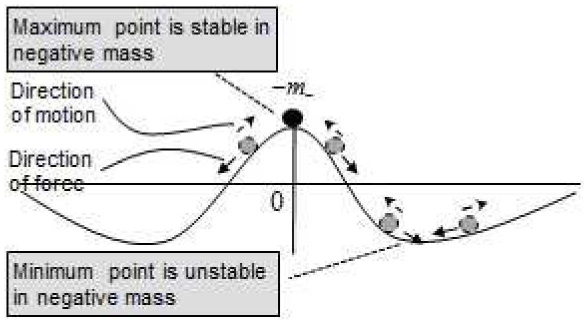


Figure 3: When there is negative mass in potential which has a point of maximum value and a point of minimum value.

2.2 Negative Mass Is Stable at the State of High Energy.

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

$$\vec{F} = -m_-\vec{a} \quad (m_- > 0) \tag{13}$$

$$\vec{a} = -\frac{\vec{F}}{m_-} \tag{14}$$

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.[15]

This is quite contrary to the case of positive mass where, stability occurs at the minimum point, i.e., at the lowest energy state.

2.3 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). Considering that it follows the laws of negative mass, being in the domain of negative energy, it cannot reach $-\frac{1}{2}\hbar\omega$ spontaneously, 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 transits 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 transition to minus infinite energy level" does not occur.

As we have examined above, "the problem of transition to minus infinite energy level" 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.

2.4 The Reason for Nonobservance of Negative Mass

Negative mass have repulsive gravitational effect with each other, unlike the attractive nature of their positive counterparts [5, 6]. Since positive mass has attractive effects with each other, so it is responsible for the large scale structure formation, such as stars and galaxies. Suppose negative mass and positive mass were to co-exist at the beginning of universe, due to the repulsive effects towards each other negative mass cannot form any massive structure and may spread out almost uniformly across the whole area of universe. In an environment of co-existence of both the 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 a galaxy structure.

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

3 Some Cosmological Problems and Utility of Negative Mass (Energy)

3.1 Initial Energy Value of the Universe

Human intuition says that the most logical evolution of the universe should be from a zero energy scenario. Therefore, in order to offset the known positive energy of matter, negative energy is needed.

$$E_T = 0 = (+E) + (-E) = (\sum m_+ c^2) + (\sum -m_- c^2) + (\sum U) = 0 \tag{15}$$

Comment on the model of Hawking, Guth and Virenkin,

The theory of 'universe birth model from nothing' by Hawking, Guth and Virenkin etc. can be explained by the fact that the gravitational potential energy offsets the mass energy.[16] Gravitational self-energy or Gravitational binding energy in case of uniform density is given by:

$$U_{gs} = -\frac{3}{5}\frac{GM^2}{R} \tag{16}$$

From Mass energy equivalence principle,

$$-\frac{3}{5}\frac{GM^2}{R_{gs}} = -Mc^2 \tag{17}$$

$$R_{gs} = \frac{3}{5}\frac{GM}{c^2} \tag{18}$$

However, Schwarzschild black hole's radius is given by $R_B = \frac{2GM}{c^2}$.

$$R_{gs} = 0.3R_B < R_B \tag{19}$$

If gravitational potential energy exactly balances the energy in matter, our universe has to be black hole. But, our universe is not black hole.

At present, the gravitational potential energy does not completely offset mass energy. And for the birth of the universe from "nothing or zero energy" and energy conservation at the birth of the universe, "negative mass", which corresponds to "negative energy", is of utmost necessity.

3.2 Problem of Infinity Mass Density in the Early Universe

The current big bang model faces a serious problem in the sense that our universe is expanding from a state, when the density was far beyond the density of black hole in the early universe.

Suppose we consider that the negative mass and positive mass came into existence together at the beginning of universe. Theory says that during Big bang all the mass of the universe came together in a cluster and occupied a very small area (of the order of a point mass). In spite of this, the cluster did not have the density as that of a black hole due to the mutual counterbalancing of density by positive mass and negative mass. Therefore, theoretically the universe could not be sucked into a singularity. This lends a stable nature to the universe and provides an opportunity for a late expansion, which we are currently experiencing.

3.3 Large Value of Vacuum Energy

The currently known value of vacuum energy is a very large quantity ($10^{111} J/m^3$) [9]. If this vacuum energy exists, there should be no reason of not experiencing it around us, which is the fact.

In the model of the pair creation of negative mass(energy) and positive mass(energy), vacuum energy will become exactly zero because vacuum is the space where pair creation and pair annihilation of positive and negative energy occurs.

3.4 Flatness Problem

Positive energy and negative energy are counterbalanced in a zero energy universe, thus explaining the fact that the universe is almost flat.[9]

3.5 Dark Energy

ΛCDM, has been gracefully accepted as our current standard model of cosmology. But neither Λ nor CDM has been successfully proven till now[7, 8, 9, 10, 11, 12, 13, 14]. 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 least the above fact is consistent with our observation.

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

3.5.1 Obsevation results

In 1998, observations by both the HSS team and SCP team resulted in the determination of negative energy density from inspected field equations devoid of cosmological constant.

The findings were as follows:

HSS(The High-z Supernova Search) team : If $\Lambda = 0$, $\Omega_M = -0.38(\pm 0.22)$ [7]

SCP(Supernova Cosmology Project) team : If $\Lambda = 0$, $\Omega_M = -0.4(\pm 0.1)$ [8]

However, "the problem of transition to minus infinity energy level" took the better of them and the two teams concluded that negative mass and negative energy level could not exist in our universe. They instead revised the field equation by inserting the cosmological constant.[7][8]

Moreover, we considered vacuum energy as the source of cosmological constant Λ, but the current result of calculation shows difference of 10^{120} times between the two, which is unprecedented even in the history of Physics.[9, 10, 11]

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

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

3.5.2 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.

$$U_T = U_{-+} + U_{--} + U_{++} \tag{20}$$

$$U_T = \sum_{i,j}(-\frac{G(-m_{-i})m_{+j}}{r_{-+ij}}) + \sum_{i<j}(-\frac{G(-m_{-i})(-m_{-j})}{r_{--ij}}) + \sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) \tag{21}$$

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

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

$$U_T = (n_- \times n_+)U_{-+} + (\frac{n_-(n_- - 1)}{2}U_{--} + \frac{n_+(n_+ - 1)}{2}U_{++}) \tag{23}$$

For example, when two pairs exist,

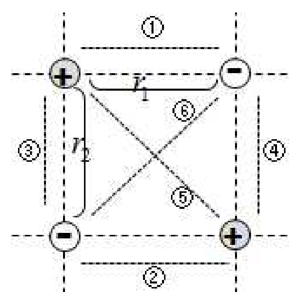


Figure 4: When two pair exists

$$\begin{aligned} U_T &= (U_1 + U_2 + U_3 + U_4) + U_5 + U_6 \\ &= (4U_{-+}) + 1U_{++} + 1U_{--} \end{aligned} \tag{24}$$

GPE shows important characteristics when negative mass and positive mass both co-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 $((-)ve, zero, (+)ve)$.

3.5.3 Logic structure of the Friedmann equation

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.

3.5.4 Computer simulation

To look into the characteristic of GPE, we used the simulation program named 'Gravitation3D' made by Roice Nelson[17] and 'G3D File Creator and Reader' made by our team.

1) Simulation setting

a)Definition of parameter : A few parameters were needed to be defined for simulation. Distance between pair creation negative energy and positive energy(distance of 1 pair) : d_0, Minimum distance between particle pairs for density modification during pair creation : d_m, Radius of pair creation range : $R_0 = 500$, Particle

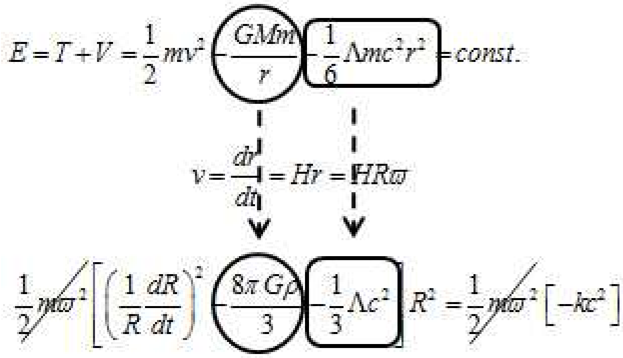


Figure 5: The Friedmann equation can derive from field equation or mechanical energy conservation equation.[9] We judge the components of the universe by gravitational effect (or GPE) rather than mass energy.

number of pair creation : $N_0 = 2,000ea(1,000pairs)$

b)Finding mean value, 1,000 particle pairs (total 2,000ea particles) were produced by random and one mean value (GPE) of each distance value was found 5 times each.

c)Verification on program : To check if the calculated results of the program were correct, we calculated the GPE when 1, 2, and 3 pairs (consist of 15ea potentials) of particles existed by hand and confirmed that this value corresponded to the calculated results of the program.

2) Simulation results

a) Distance of 1 pair (d_0) = 0.01, 0.10

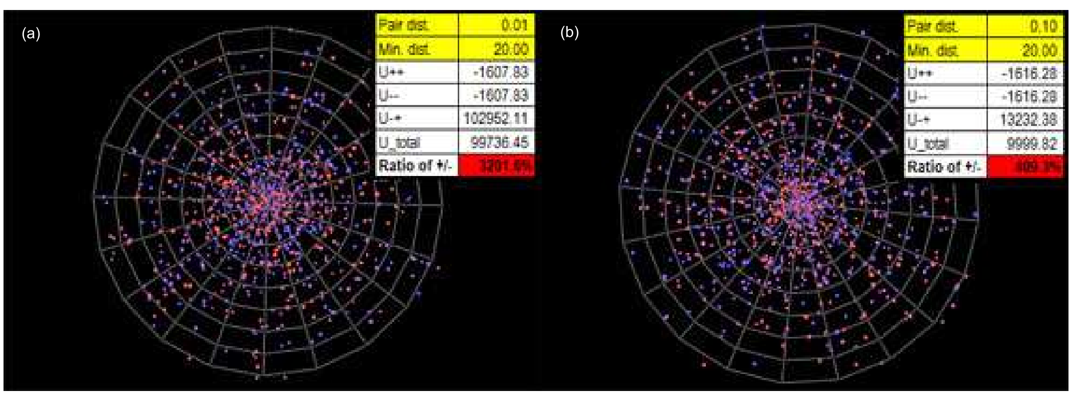


Figure 6: (a)$d_0 = 0.01$, (b)$d_0 = 0.10$

One particle pair corresponds to the cluster of galaxies in the universe structure. It was found out that U_{-+} value having positive value could be much higher than $|U_{++}| + |U_{--}|$. Thus, even though the size of positive mass and negative mass was equal, it could be known that repulsive GPE could be much higher than attractive GPE.

This discovery implies that our belief that size of gravitational effect and size of components(mass-energy) of the universe would always 1:1 correspond was wrong.

b) Distance of 1 pair (d_0) = 0.19, 10.00

Dark matter and matter correspond to negative gravitational potential because they have attractive gravitational potential and dark energy correspond to positive gravitational potential because it produces repulsive

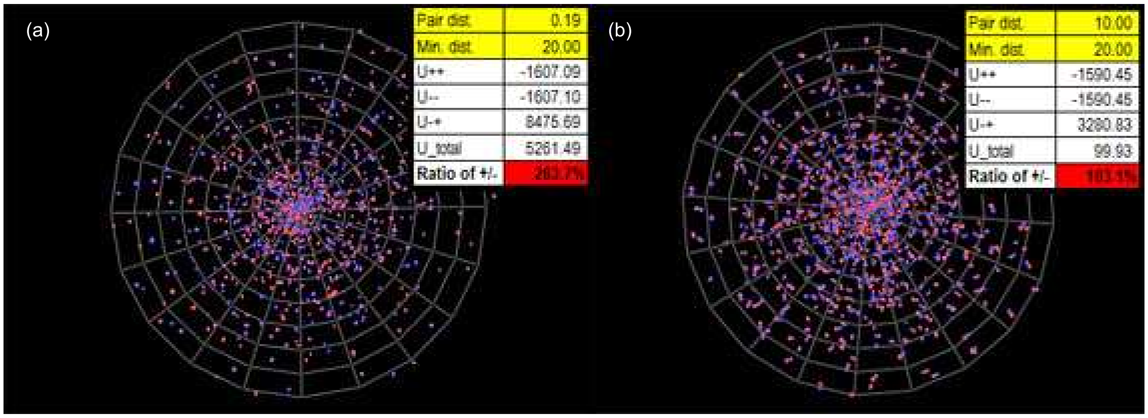
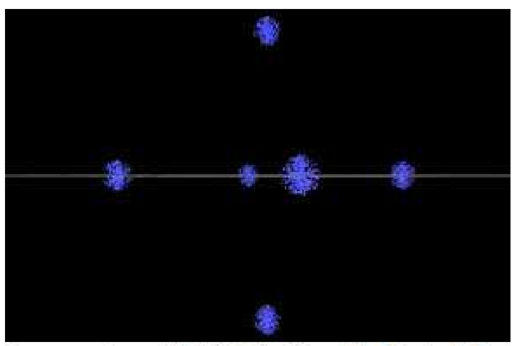


Figure 7: (a)$d_0 = 0.19$, (b)$d_0 = 10.00$

effect. Therefore, observation ratio of current universe is 72.1/27.9 = 2.584.[18] This shows similar value to 2.63 which was found above. If conditions change, ratio of negative gravitational potential and positive gravitational potential can have various values close to 2.58.

c) WMAP's result

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	1.000
Dark Matter	U--	23.3	5.065
Dark Energy	U-+	72.1	15.674
Ratio +/-			2.584

	Simulation	Ratio
U++	- 83.2	1.000
U--	- 459.6	5.523
U-+	1286.9	15.463
		2.371

Figure 8: $m_+ = +100$ X 6 = + 600. (±1200,0,0), (0,±1200,0), (0,0,±1200), each 100. $-m_- = (-0.2$ X 500) X 6 $=-600$. Negative mass distribution : center1,2(±1200,0,0), center3,4(0,±1200,0), center5,6(0,0,±1200), negative mass is generated randomly within R=3 ∼120, min. distance = 8.

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 [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).[18]

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 matter exists without the need for mass energy 15 times more than the mass energy of matter, this may be able to explain the effect of dark energy.

3.6 Dark Matter

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

3.6.1 Centripetal force effect

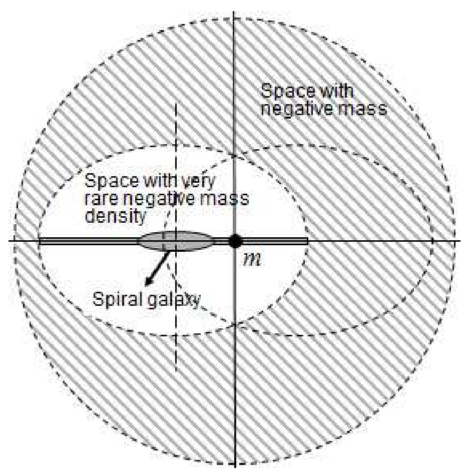


Figure 9: The structure of the galaxy surrounded by negative mass that is distributed equally. Negative mass is surrounding the galaxy that consists of positive mass. The white area is the area where negative mass almost does not exist.

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.

1) If we assume that the empty space is filled with both negative mass and positive mass of the same density then,

Total energy of the white empty space = 0 = $(+mc^2) + (-mc^2) = 0$

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

3) The remaining positive mass is distributed over the white area at the density of negative mass. 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.[4]

Therefore, the effect of negative mass that remains outside of the galaxy is compressive to 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.

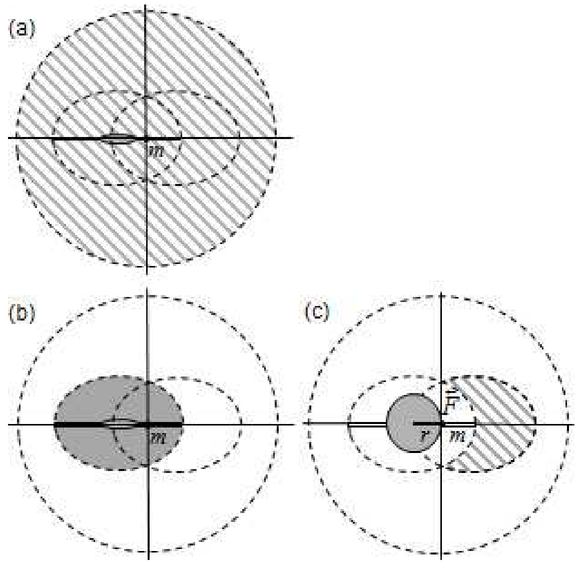


Figure 10: The effect of negative mass that remains outside of the galaxy can make it possible to be approximate to the gravity generated by the distribution of positive mass within the radius r in the galaxy.

This 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 above analysis was conducted under the assumption that the distribution of negative mass outside the galaxy is in a uniform manner. However, the galaxy actually consists of positive mass that affects the negative mass outside the galaxy gravitationally, as a result of which the density of negative mass outside the galaxy is not uniform.

3.6.2 The problem of nonobservance of galaxy or cluster of galaxies consisting 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.

3.6.3 Computer simulation

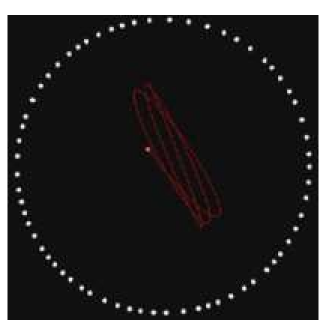


Figure 11: White : negative mass(fixed), Red : positive mass(free). The positive mass vibrates.

If the negative mass is disposed at the outline, the positive mass vibrates. Therefore a kind of centripetal force exists. This corresponds to the "centripetal force" when considering rotation of the galaxy.

3.7 New Field Equation and Friedmann Equation.

Einstein's field equation is given by :

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G T_{\mu\nu} \tag{25}$$

We need to frame a 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.
$U_T = U_{++} + U_{--} + U_{-+}$

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

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G(^{++}T_{\mu\nu} + {}^{--}T_{\mu\nu} + {}^{-+}T_{\mu\nu}) \tag{26}$$

At this time, we should consider that negative mass surrounds the galaxy or galaxy clusters composed of positive mass.

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

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G(^{++}T_{\mu\nu}) \tag{27}$$

Thus, we get an Einstein's field eq.

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

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G(^{++}T_{\mu\nu} + {}^{--}T_{\mu\nu} + {}^{-+}T_{\mu\nu}) \tag{28}$$

We need solve this new field eq.

The existing physical world uses a temporary solution. We introduce $+\rho_\Lambda$ corresponding to positive mass in relation to dark energy to avoid negative mass(energy) as source of gravitation. However, this cannot produce accelerating expansion effect. So we introduce the pressure term($\frac{3P_\Lambda}{c^2}$) and the density of negative energy is shifted to this pressure. ("negative pressure" is introduced).[9]

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

$$\rho_\Lambda + \frac{3P_\Lambda}{c^2} = \rho_\Lambda + \frac{3(-\rho_\Lambda c^2)}{c^2} = -2\rho_\Lambda \tag{29}$$

The outcome is that negative energy exists from the beginning of the universe. The accelerating expansion of the universe means that there exists 'density of negative energy' in the right side of acceleration equation.

Friedmann equation utilized the concept of mechanical energy conservation applied to positive mass. This gave rise to the equation of motion in the universe that is composed of **'one kind'** of gravitational characteristic (positive matter source).

However, **if there exist 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, then energy content of the universe is given by,

$$E = T + V = \sum \frac{1}{2} m_{+i} {v_{+i}}^2 + \sum (-\frac{1}{2} m_{-j} {v_{-j}}^2) + U_{++} + U_{--} + U_{-+} = const. \tag{30}$$

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

$$E = \sum \frac{1}{2} m_{+i} {v_{+i}}^2 + \sum_{i<j} (-\frac{G m_{+i} m_{+j}}{r_{++ij}}) + \sum_{i,j} (+\frac{G m_{-i} m_{+j}}{r_{-+ij}}) \tag{31}$$

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

The present cosmological constant can be obtained by adding potential energy $U_\Lambda \equiv -\frac{1}{6}\Lambda m c^2 r^2$ to mechanical energy conservation equation.[9] Refer to figure 5.

$$\vec{F}_\Lambda = -\frac{\partial U_\Lambda}{\partial r}\hat{r} = +\frac{1}{3}\Lambda m c^2 r \hat{r} \tag{32}$$

Potential energy, which belongs to present dark energy Λ, has a negative value, and generates repulsive force.

But,

i)This dark energy term or potential energy term diverge, when 'r' gets bigger.

ii)We don't have a basis for this potential energy.

On the other hand, dark energy term(refer to eq.(44),(47)) proposed by "pair creation model of positive energy and negative energy" is

$$U_{T\Lambda} = U_{-+} = +k_h(t)\frac{G {M_+}^2}{r} \tag{33}$$

$$\vec{F}_{T\Lambda} = -\frac{\partial U_{-+}}{\partial r}\hat{r} = +k_h(t)\frac{G {M_+}^2}{r^2}\hat{r} \tag{34}$$

This force $\vec{F}_{T\Lambda}$ is assumed to accelerate total M(=$2M_+$) in the spherical shell.

$$\vec{F}_{T\Lambda} = +k_h(t)\frac{G {M_+}^2}{r^2}\hat{r} = 2M_+ \vec{a}_\Lambda \tag{35}$$

$$\vec{a}_\Lambda = +k_h(t)\frac{G M_+}{2r^2}\hat{r} = \frac{2\pi G k_h(t)}{3}\rho_+ r\hat{r} \tag{36}$$

$$\vec{F}_\Lambda = m\vec{a}_\Lambda = +\frac{2\pi G k_h(t)}{3}\rho_+ m r\hat{r} \tag{37}$$

We can get a very similar result with the ΛCDM model. Also, it has a better condition. GPE U_{-+}, which belongs to this dark energy, has a positive value, and generates repulsive force.

i) This dark energy term or potential energy term converge, when 'r' gets bigger.

ii) We can explain the basis for this term. It is positive GPE.

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 in their movement compared to conventional models of single gravitational sources. Thus, we need to set up new Friedmann equation and field equation to solve problems.

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

3.8 Theoretical Demonstration of Constituent Ratio of the Universe

3.8.1 GPE in the universe that consists of negative mass and positive mass

Let's find the value of total GPE of the universe for the rather simple case, when matter is evenly distributed and then generalize the result for the state that resembles the current universe.

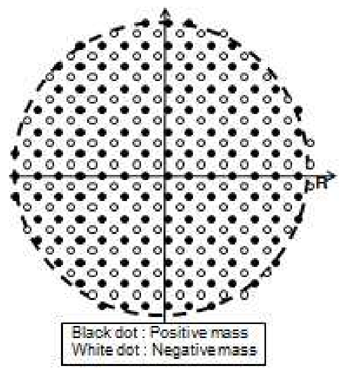


Figure 12: Universe where negative mass(energy) and positive mass(energy) are evenly distributed.

The present cosmological constant can be obtained by adding potential energy $U_\Lambda = -\frac{1}{6}\Lambda mc^2 r^2$ to mechanical energy conservation equation.

If we insert 'new potential energy term' into mechanical energy conservation equation, we will get a similar term such as $-\frac{1}{3}\Lambda c^2$ term.

At this time, let's insert the new gravitational potential energy term (eq.(22)) into it.

The current energy ratios of U_{++}, U_{--}, U_{-+} is (4.9% : 26.8% : 68.3%) between each other. So our estimation must lead us close to the above values, if not equal.

Total GPE U_T is as shown in equation (22). As we believe that the three GPE components corresponds to matter, dark matter, and dark energy, the following formula can be drawn.

$$U_T = \sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i<j}(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}) + \sum_{i,j}(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}) \quad (38)$$

$$= U_m + U_d + U_\Lambda \quad (39)$$

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

As positive masses are evenly distributed in radius R, $U_m = -\frac{3}{5}\frac{GM_+{}^2}{R}$ [4]

As negative masses are evenly distributed in radius R, $U_d = -\frac{3}{5}\frac{GM_-{}^2}{R}$

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

$$U_S = \sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i<j}(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}) + \sum_{i,j}(-\frac{Gm_{-i}m_{+j}}{r_{-+ij}}) \quad (40)$$

$$= U_m + U_d - U_\Lambda \quad (41)$$

$$= -\frac{3}{5}\frac{GM^2}{R} \quad (42)$$

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

$$U_m + U_d - U_\Lambda = -\frac{3}{5}\frac{GM_+{}^2}{R} - \frac{3}{5}\frac{GM_-{}^2}{R} - U_\Lambda = -\frac{3}{5}\frac{GM^2}{R} \quad (43)$$

$(M_+ = M_- \geq 0, M = M_+ + M_-)$
Therefore, it can be inferred that the dark energy itself will have the following forms.

$$U_\Lambda = +k_h(t)\frac{GM^2}{R} \tag{44}$$

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 asymmetrical. For this reason, coefficient $k_h(t)$ is 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]

$$\frac{U_m + U_d}{U_\Lambda} = -b_{Planck} = \frac{(-4.9) + (-26.8)}{68.3} \simeq -0.464 \tag{45}$$

From the equation (41), (42)

$$(-b-1)U_\Lambda = -\frac{3}{5}\frac{GM^2}{R} \tag{46}$$

$$U_\Lambda = \frac{1}{(1+b)}\frac{3}{5}\frac{G(2M_+)^2}{R} = +k_h(t)\frac{G{M_+}^2}{R} \tag{47}$$

From observation we get: Planck's $k_h(t_0) = 1.638$, WMAP's $k_h(t_0) = 1.728$

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

$$U_m = U_d = -\frac{3}{5}\frac{G{M_+}^2}{R} = -\frac{3}{5}\frac{G{M_-}^2}{R} \tag{48}$$

$$U_m + U_d - U_\Lambda = -\frac{3}{5}\frac{G{M_+}^2}{R} - \frac{3}{5}\frac{G{M_-}^2}{R} - U_\Lambda = -\frac{3}{5}\frac{GM^2}{R} \tag{49}$$

$$U_\Lambda = \frac{3}{5}\frac{G(2M_+)^2}{R} - \frac{3}{5}\frac{G{M_+}^2}{R} - \frac{3}{5}\frac{G{M_+}^2}{R} = (-2) \times (-\frac{3}{5}\frac{G{M_+}^2}{R}) = -2U_m \tag{50}$$

Therefore, total GPE is

$$U_T = U_{++} + U_{--} + U_{-+} = U_m + U_d + U_\Lambda = 0 \tag{51}$$

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

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -1 : -1 : +2 = 25\% : 25\% : 50\% \tag{52}$$

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.

It was showed that the universe was expanding even in the state when total GPE is 0, that is, a complete zero energy state. This is because GPE for the motion of positive mass is not 0 although total GPE is 0.

Also, looking into the numerical calculation of chapter 3.5.4, it can be seen that positive gravitational potential value U_{-+} can have much higher values than negative gravitational potential values.

From the equations (38) and (39) we get,

$$\sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i,j}(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}) = U_m + U_\Lambda \tag{53}$$

There are two GPE terms that include positive mass and the sum of these is not equal to zero.

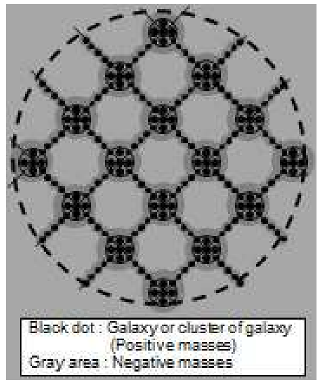


Figure 13: The current universe presumed in this model: Although the positive mass(black dot) constitute galaxy or cluster of galaxies and negative mass(gray) are almost evenly distributed in the entire universe, it is presumed that the density of negative mass(dark gray) near the galaxy would be higher than that of negative mass in the void area(gray), because negative mass receives attractive gravitational effect from large positive mass. Refer to chapter 2.1.1

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

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

$U_{++}=-\frac{3}{5}\frac{GM_+{}^2}{R}$ needs to be corrected because it's 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

$$U_T = U_S = U_{self-Sun} + U_{self-Earth} + U_{Sun-Earth} \tag{54}$$

$$U_{Sun-Earth} = U_S - (U_{self-Sun} + U_{self-Earth}) \tag{55}$$

However, the particles that constitute the sun always move together because they are gravitationally strongly bonded. Likewise, the particles that constitute the earth always move together because they also share strong gravitational bond. Therefore, what determines the movement between the sun and the earth is only the 'GPE between the sun and the earth'. In other words, the GPE of objects that have strong gravitational bonds between them, does not change. It means that the GPE of objects that are gravitationally strongly bonded does not contribute to the movement of other objects.

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

$$U_{++} = U_m = -\frac{3}{5}\frac{GM_+{}^2}{R} - N(-\frac{3}{5}\frac{Gm_+{}^2}{r_0}) = -\frac{3}{5}\frac{GM_+{}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] \tag{56}$$

*M_+ : Total mass of matters within Hubble's radius

*R : Hubble's radius

*m_+ : Average mass of objects strongly bond gravitationally (Probably, mass of galaxy 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 to each other. Accordingly, if we assume that the entire universe is almost evenly distributed,

$$U_{--} = U_d = -\frac{3}{5}\frac{G{M_-}^2}{R} = -\frac{3}{5}\frac{G{M_+}^2}{R} \tag{57}$$

$$\frac{U_{--}}{U_{++}} = \frac{U_d}{U_m} = \frac{-\frac{3}{5}\frac{G{M_-}^2}{R}}{-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = \frac{1}{1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}} = c \tag{58}$$

$$N(\frac{m_+}{M_+})^2\frac{R}{r_0} = 1 - \frac{1}{c} \tag{59}$$

$$N(\frac{{\rho_{m+}}^2{r_0}^5}{{\rho_{M+}}^2R^5}) = 1 - \frac{1}{c} \tag{60}$$

From observation: $c_{WMAP} = \frac{23.3}{4.6} \simeq 5.065$ [18], $c_{Planck} = \frac{26.8}{4.9} \simeq 5.469$[19]

Now, let's calculate dark energy:
If $U_S \approx -\frac{3}{5}\frac{GM^2}{R}$,
From the equation (41), we get,

$$-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - \frac{3}{5}\frac{G{M_-}^2}{R} - U_\Lambda \approx -\frac{3}{5}\frac{GM^2}{R} \tag{61}$$

$$U_\Lambda \approx +\frac{3}{5}\frac{GM^2}{R} - \frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - \frac{3}{5}\frac{G{M_-}^2}{R} \tag{62}$$

a) **WMAP:**

$$\begin{aligned} U_\Lambda &\approx +\frac{3}{5}\frac{G(2M_-)^2}{R} - \frac{3}{5}\frac{G{M_-}^2}{R}(\frac{1}{5.065}) - \frac{3}{5}\frac{G{M_-}^2}{R} \\ &= (4 - \frac{1}{5.065} - 1)\frac{3}{5}\frac{G{M_-}^2}{R} \\ &= (-2.803)U_d \end{aligned} \tag{63}$$

Therefore,

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.197 : -1 : +2.803 = 4.93\% : 25.00\% : 70.07\% \tag{64}$$

It's very close to observed WMAP value.

b) **Planck:**

$$\begin{aligned} U_\Lambda &\approx +\frac{3}{5}\frac{G(2M_-)^2}{R} - \frac{3}{5}\frac{G{M_-}^2}{R}(\frac{1}{5.469}) - \frac{3}{5}\frac{G{M_-}^2}{R} \\ &= (-2.817)(-\frac{3}{5}\frac{G{M_-}^2}{R}) \\ &= (-2.817)U_d \end{aligned} \tag{65}$$

Therefore,

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.183 : -1 : +2.817 = 4.58\% : 25.00\% : 70.43\% \tag{66}$$

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

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

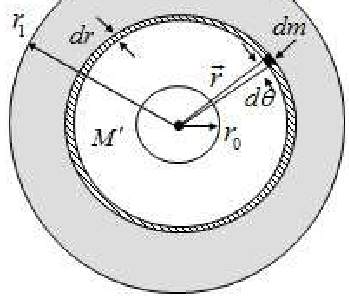


Figure 14: $0 \sim r_0$: positive mass distribution, $r_0 \sim r_1$: negative mass distribution

From the motional characteristics of negative mass and positive mass, great positive mass gives attractive effect to the individual negative mass. Therefore, negative mass exists with higher density near the galaxies or cluster of galaxies that constitute positive mass. Refer to chapter 2.1.1.

$$U_{++} = U_m = -\frac{3}{5}\frac{GM_+{}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2 \frac{R}{r_0}\right] \tag{67}$$

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

$$U_S = -\frac{G(4\pi\rho)^2}{3}\left[\frac{1}{5}{r_1}^5 - \frac{{r_0}^3}{2}{r_1}^2 + \frac{3}{10}{r_0}^5\right] \tag{68}$$

However, part of the negative mass are evenly distributed in the entire universe like figure 13, and some are distributed near the cluster of galaxies that are constituted by positive mass.

$$M_- = m_{-u} + Nm_- \tag{69}$$

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

$$U_{--} = U_d = -\frac{3}{5}\frac{GM_-{}^2}{R} - N(-\frac{G(4\pi\rho_-)^2}{3}\left[\frac{1}{5}{r_1}^5 - \frac{{r_0}^3}{2}{r_1}^2 + \frac{3}{10}{r_0}^5\right]) \tag{70}$$

$$U_{--} = -\frac{3}{5}\frac{GM_-{}^2}{R}\left[1 - \frac{5NR(4\pi\rho_-)^2}{9M_-{}^2}\left[\frac{1}{5}{r_1}^5 - \frac{{r_0}^3}{2}{r_1}^2 + \frac{3}{10}{r_0}^5\right]\right] \tag{71}$$

$$\frac{U_{--}}{U_{++}} = c = \frac{-\frac{3}{5}\frac{GM_-{}^2}{R}\left[1 - \frac{5NR(4\pi\rho_-)^2}{9M_-{}^2}\left[\frac{1}{5}{r_1}^5 - \frac{{r_0}^3}{2}{r_1}^2 + \frac{3}{10}{r_0}^5\right]\right]}{-\frac{3}{5}\frac{GM_+{}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} \tag{72}$$

$$c = \frac{1 - \frac{5NR(4\pi\rho_-)^2}{9M_-{}^2}\left[\frac{1}{5}{r_1}^5 - \frac{{r_0}^3}{2}{r_1}^2 + \frac{3}{10}{r_0}^5\right]}{\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} \tag{73}$$

Currently, U_{--} and U_{-+} possess a 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.

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

$$U_\Lambda \approx \frac{3}{5}\frac{GM^2}{R} + U_m + U_d \tag{74}$$

$$= \frac{3}{5}\frac{GM_+{}^2}{R}\left(4 - \left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - c\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]\right)$$

$$= \frac{3}{5}\frac{GM_+{}^2}{R}\left((3-c) + (1+c)N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right)$$

$$\frac{U_\Lambda}{U_m} = \frac{\left[(3-c) + (1+c)N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]}{\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = d \tag{75}$$

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

$$\frac{[(3-c) + (1+c)\chi_h]}{(1-\chi_h)} = d \tag{76}$$

$$\chi_h = \frac{c+d-3}{c+d+1} \tag{77}$$

i) **WMAP**

$$\chi_{hW} = \frac{c+d-3}{c+d+1} \simeq \frac{5.065 + 15.673 - 3}{5.065 + 15.673 + 1} = 0.816 \tag{78}$$

$$U_m \approx (-0.184)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{79}$$

$$U_d \approx (-0.932)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{80}$$

$$U_\Lambda \approx (+2.884)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{81}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.184 : -0.932 : +2.884 = 4.6\% : 23.3\% : 72.1\% \tag{82}$$

ii) **Planck**

$$\chi_{hP} = \frac{c+d-3}{c+d+1} \simeq \frac{5.469 + 13.938 - 3}{5.469 + 13.938 + 1} = 0.804 \tag{83}$$

$$U_m \approx (-0.196)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{84}$$

$$U_d \approx (-1.071)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{85}$$

$$U_\Lambda \approx (+2.733)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{86}$$

It's reasonable to assume that the upper limit of coefficient U_d is 1. When the upper limit of coefficient U_d is corrected as 1, the value is,

$$U_m \approx (-0.183)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{87}$$

$$U_d \approx (-1.000)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{88}$$

$$U_\Lambda \approx (+2.549)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{89}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.183 : -1.000 : +2.549 = 4.9\% : 26.8\% : 68.3\% \tag{90}$$

b) If $U_\Lambda \approx (-2)(-\frac{3}{5}\frac{GM_+{}^2}{R})$

This value(eq.(50)) is the value of dark energy obtained when positive mass(energy) and negative mass(energy) are evenly distributed. Refer to chapter 3.8.2.

As it is seen that the universe transforms locally from uniform state to non-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.

$$\frac{U_\Lambda}{U_m} = \frac{-\frac{3}{5}\frac{G{M_+}^2}{R} \times (-2)}{-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = \frac{-2}{\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = d \tag{91}$$

$$N(\frac{m_+}{M_+})^2\frac{R}{r_0} = 1 + \frac{2}{d} \tag{92}$$

i) **WMAP**

$$\chi_{hW} = 1 + \frac{2}{d} \simeq 1 + \frac{2}{-15.673} = 0.872 \tag{93}$$

$$U_m \approx (-0.128)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{94}$$

$$U_d \approx (-0.648)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{95}$$

$$U_\Lambda \approx (+2.000)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{96}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.128 : -0.648 : +2.000 = 4.6\% : 23.3\% : 72.1\% \tag{97}$$

ii) **Planck**

$$\chi_{hP} = 1 + \frac{2}{d} \simeq 1 + \frac{2}{-13.938} = 0.857 \tag{98}$$

$$U_m \approx (-0.143)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{99}$$

$$U_d \approx (-0.782)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{100}$$

$$U_\Lambda \approx (+2.000)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{101}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.143 : -0.782 : +2.000 = 4.9\% : 26.8\% : 68.3\% \tag{102}$$

3.8.4 Entire change

Uniformly distribution –> locally non-uniform distribution

1) Uniformly distribution

$$U_{++} = U_m = (-1)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{103}$$

$$U_{--} = U_d = (-1)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{104}$$

$$U_{-+} = U_\Lambda = (+2)\frac{3}{5}\frac{G{M_+}^2}{R} \tag{105}$$

$$U_T = U_{++} + U_{--} + U_{-+} = U_m + U_d + U_\Lambda = 0 \tag{106}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -1 : -1 : +2 = 25\% : 25\% : 50\% \tag{107}$$

2) Locally non-uniform distribution

i) **WMAP**

$$U_{++} = U_m \approx (-0.128 \sim -0.184)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{108}$$

$$U_{--} = U_d \approx (-0.648 \sim -0.932)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{109}$$

$$U_{-+} = U_\Lambda \approx (+2.000 \sim +2.884)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{110}$$

ii) **Planck**

$$U_{++} = U_m \approx (-0.143 \sim -0.183)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{111}$$

$$U_{--} = U_d \approx (-0.782 \sim -1.000)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{112}$$

$$U_{-+} = U_\Lambda \approx (+2.000 \sim +2.549)\frac{3}{5}\frac{GM_+{}^2}{R} \tag{113}$$

$$U_T = U_{++} + U_{--} + U_{-+} = U_m + U_d + U_\Lambda > 0 \tag{114}$$

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = 4.9\% : 26.8\% : 68.3\% \tag{115}$$

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

3.9 Computer simulation - matter : dark matter : dark energy ratio depending on the expansion of the universe

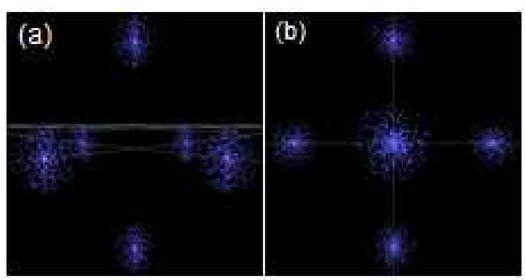


Figure 15: Distribution of six galaxies: a)Aerial view, b)Plane figure. Initial state distribution: m_+ = +100 X 6 = + 600. Center1,2(±100,0,0), center3,4(0,±100,0), center5,6(0,0,±100), each 100. $-m_-$ =(-0.2 X 500) X 6 =−600. Negative mass distribution : center1,2(±100,0,0), center3,4,(0,±100,0), center5,6(0,0,±100), negative mass is generated randomly 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.

The above experiment shows the state when the cluster of galaxies that constitute positive mass are 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 of expansion of the universe, the shape of galaxies is maintained.

i) Surprisingly, the ratio of $U_{++}(U_m), U_{--}(U_d)$, and $U_{-+}(U_\Lambda)$ changes simply when the universe expands according to Hubble's law.

Table 1: Uniquely, there are changes in the ratio of $U_{++}(U_m)$, $U_{--}(U_d)$, and $U_{-+}(U_\Lambda)$ 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.

R	100	1100	2100	3100	4100	5100	6100	7100	8100	9100
U_{++}	-998.53	-90.78	-47.55	-32.21	-24.35	-19.58	-16.37	-14.06	-12.33	-10.9
U_{--}	-1333.99	-473.15	-424.61	-410.63	-402.08	-394.28	-391.77	-393.06	-389.54	-388.5
U_{-+}	3101.93	1319.36	1212.93	1191.85	1170.89	1157.14	1147.28	1146.86	1143.88	1144.5
U_{Tot}	769.41	755.44	740.77	749.01	744.46	743.27	739.14	739.74	742.01	745.0
+GPE/-GPE	1.33	2.34	2.57	2.69	2.75	2.80	2.81	2.82	2.85	2.86
	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
$U_{++}(U_m)$	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
$U_{--}(U_d)$	-1.34	-5.21	-8.93	-12.75	-16.51	-20.14	-23.93	-27.95	-31.60	-35.4
$U_{-+}(U_\Lambda)$	3.11	14.53	25.51	37.00	48.08	59.10	70.09	81.55	92.79	104.3

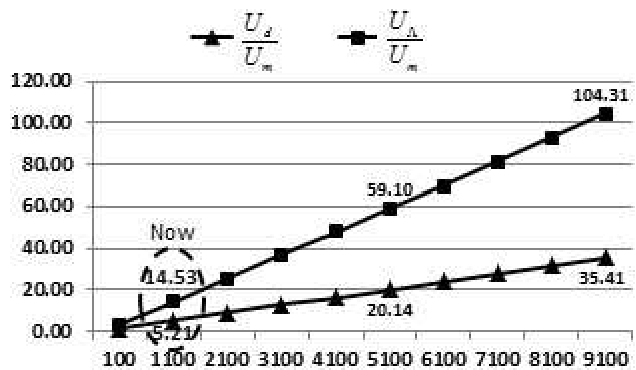


Figure 16: $\frac{U_d}{U_m}$ and $\frac{U_\Lambda}{U_m}$

ii) 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.

4 Discussion and Conclusion

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 till now. [9, 10, 11, 12, 13, 14]

The reason why the entire explanation of ΛCDM at this point of time seems to be right is that the repulsive gravitation effect corresponding to Λ and the attractive gravitational effect corresponding to cold dark matter are required. However, this can also be properly explained by this model (Pair creation of positive energy and negative energy). As a result, the negative mass(energy) satisfies energy conservation and should be an indispensable concept.

ΛCDM model expects that the ratio of matter and dark matter will be constant, but this model suggests that as the universe expands, the gravitational effect of matter vs dark matter differs.

Finally, in the current mainstream physical description, we assert, that the amount of dark matter gradually increases. Even though the gravitational effects of dark matter increase, the gravitational effects corresponding to dark energy also increase. So the universe is supposed to continue to accelerate its expansion. However, GPE is a conserved quantity and decreases as the distance increases, so it appears to be lower than the ΛCDM model in acceleration.

Therefore, the past and the future predicted by two models (ΛCDM and pair creation) are quite different.

$\frac{\Omega_d}{\Omega_m} = 1 \Rightarrow \frac{\Omega_d}{\Omega_m} = 5.47$

Thus, it is necessary to investigate the change of the ratio $\frac{\Omega_d}{\Omega_m}(t)$

We need to make new Friedmann equations and new field equation on the assumption that negative energy(mass) and positive energy(mass) coexist and compare two models.

Acknowledgments
We whole-heartedly thank Nembo Buldrini for helping us with computer simulation.

References

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

[2] Dirac, Paul A. M.. Theory of Electrons and Positrons. The Nobel Foundation. (1993).

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

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

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

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

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

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

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

[10] Sean Carroll. The cosmological constant. Living Reviews in Relativity.(2001).

[11] D. Sapone, Dark energy in practice. Int. J. Mod. Phys. **A25**, 5253 (2010).

[12] Matts Roos. Dark Matter : The evidence from astronomy, astrophysics and cosmology. (2010) [arXiv:1001.0316]

[13] E. Aprile et al. [The XENON100 Collaboration]. Dark Matter Results from 100 Live Days of XENON100 Data. Phys. rev. Lett. 107, 131302(2011).

[14] LUX Collaboration. First results from the LUX dark matter experiment at the Sanford Underground Research Facility. (2013). [arXiv:1310.8214]

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

[16] Stephen Hawking. *A Brief History of Time*(Bantam Dell Publishing Group, New York, 1992).

[17] Roise Nelson. [http://www.gravitation3d.com]

[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]