Negative mass is stable at the state of high energy

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All the while, the field of physics did not seriously consider the possibility of existence of negative mass at the general state [1–4]. The standard explanation about negative mass is, if energy level of negative exists, that the state of low energy is stable, and the lowest state of energy is minus infinity, so the positive mass of all emits energy, and it will transit 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 became the strong proof for the nonexistence of the negative mass and the energy level of negative. We have taken this as the natural common sense and teach it to students. At the center of this background, there is the fundamental proposition that "State of low energy is stable" (SLES) [2], [3]. In this paper, we show that the SLES proposition is an incomplete one, and in case of a positive mass, it is stable at the low state, whereas, in case of negative mass, it is stable at the high state [6]. Due to this, the problem of the transition of the energy level of minus infinity (PTEMI) does not occur, and therefore, in our universe, the existence of negative mass is possible. Moreover, we will show that negative mass provides a qualitative explanation for dark matter and dark energy, which are the biggest problem for Cosmology at the present.

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I. Introduction

From the analysis of harmonic oscillation in Classical Mechanics [2], the validity of the SLES proposition seemed clear, and from the perspective of Quantum Mechanics also, the justification of the SLES proposition was verified by the process where the elementary particles at the high energy level emitted energy and succeeded to the lower energy level [3]. Therefore, this proposition gained the greatly high level of credibility in Physics, and it has been quoted for explanations [1–3] in numerous situations of Physics. Especially, this proposition has been performing as the criteria for making a judgment when judging whether a solution to the energy of negative exists or not [3] [5] [7].Great Dirac also predicted that in case when negative energy level existed, the PTEMI would occur from this SLES proposition, so in order to avoid this kind of collapse, he escaped this problem by supposing that the negative energy level of the vacuum was all occupied [5] [7].

In 1957, Professor Bondi examined the characteristics of the negative mass and positive mass motions from the perspective of General Relativity [8], and after, Forward looked into a propulsion method, using negative mass [9]. Also, there are researches that studied negative mass in relation to the recent cosmological phenomena [10–12].

Nevertheless, even to this day, fifty years later, we are negative 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 PTEMI ultimately. Until the present, when explaining about the relativistic total energy [2] in a Classical Mechanics class or explaining about Dirac's positron [3] and antimatter in a Modern Physics or Elementary Particle Physics classes, we explain the PTEMI with the proposition and consequently teach that negative mass and negative energy do not exist in our universe (or in the general state).

However, through this research, we have found that the underlying proposition SLES is an incomplete one and that when applying this proposition to negative energy and negative mass, its application is wrong without any practical analysis. Via the analysis of Harmonic oscillation, in case of positive mass, energy is stable at the minimum point when energy is low [2], [3], but in case of negative mass, it is stable at the maximum point, and at the maximum point, it does harmonic oscillation; consequently, the PTEMI does not occur, and thus, our universe can exist without collapsing, even if negative mass and the corresponding energy level of negative exist.

Moreover, negative mass provides explanation for the dark energy related to the universe expansion and acceleration and also qualitative explanation for several characteristics of the dark matter that show strange natures.

II. The basic characteristics of negative mass' motion

A. The law of motion of negative mass and neg-

ative mass

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

$$-m_1\vec{a}_1 = -G\frac{(-m_1)(-m_2)}{r^2}\hat{r} \quad (1)$$

$$\vec{a}_1 = +G\frac{m_2}{r^2}\hat{r} \quad (2)$$

$$-m_2\vec{a}_2 = -G\frac{(-m_1)(-m_2)}{r^2}\hat{r} \quad (3)$$

$$\vec{a}_2 = +G\frac{m_1}{r^2}\hat{r} \quad (4)$$

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. [8], [9] The force is attraction($-Gm1m2/r^2$), thus the potential energy between them has negative value.

B. The law of motion of negative mass and positive mass

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

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

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

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

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

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 [8], [9]. 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 a2 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.

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.

Let's take a look at the case where the absolute value of the positive mass is very bigger than the absolute value of the negative mass.

$$m_2 >> |-m_1|$$

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

$$\vec{a}_2 = G\frac{m_1}{r^2}\hat{r} \approx 0 \quad (10)$$

The acceleration of the negative mass $-m_1$ is $\vec{a}_1 = -G\frac{m_2}{r^2}\hat{r}$. Yet, this is the same as the acceleration of the positive mass that has small size around a massive positive mass. In other words, if there is the minimalist negative mass on the surface of the earth, this means that it falls in the direction of the center of the earth like the positive mass. The motion of negative mass around the massive positive mass is very similar to that of the positive mass around the massive positive mass.

If there is negative mass around a massive positive mass, then the negative mass gets affected by the attractive effect, and consequently, it becomes clustered around the massive positive mass.

This characteristic seems to be related to the highly strange natures that the dark matter currently has. For more detailed information, refer to Chapter III-C.

C. Negative mass follows the conservation of energy and conservation of momentum [8], [9]

D. Negative mass is the solutions of the relativistic total energy equation and Dirac equation [5], [7], [13]

It is well known that from $E^2 = (m_0c^2)^2 + (pc)^2$, $E = -\sqrt{(m_0c^2)^2 + (pc)^2}$. In other words, negative energy is also a solution.

E. Negative mass is stable at the state of high energy! [6]

1. The interpretation of negative mass from the perspective of Classical Mechanics

Nature prefers stable state, and has the tendency to go to stable state. Additionally, this can be expressed

in another way that nature prefers low energy state, and has the tendency to go to low energy state. Such an idea is frequently used as a logic which denies the existence of negative mass. That is, if there is negative mass and negative energy level, negative mass spontaneously emits energy to be stable, and goes to energy state of minus infinite, so finally it is confronted by catastrophe.

In case of positive mass, stable state means low energy state, therefore it is not necessary to divide which one nature prefers among two states (stable state and low energy state). By the way, does stable state mean low energy state also in case of negative mass?

We can get an answer, if we examine Harmonic oscillation

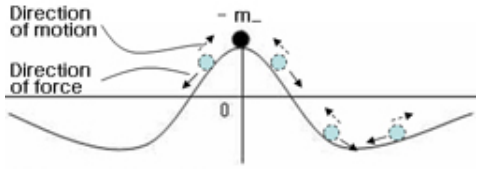

Figure 3: When there is negative mass in potential which has a point of maximum value and a point of minimum value. $\vec{F} = -m_-\vec{a}$, $\vec{a} = -\frac{\vec{F}}{m_-}$,$(m_- > 0)$. The acceleration of negative mass is opposite of the direction of force, and in case of negative mass, it does harmonic oscillation at the maximum point and is stable at the maximum point.

Let's think of the negative mass that 1-dimensional vibration. Suppose that there is the maximum point in this vibration and that the restoring force acting on the negative mass around this maximum point or the origin is the function only for the displacement [2].

In the vicinity of the origin, F(x), the restoring force acting on the negative mass develops as the following

$$F(x) = F(0) + \frac{x}{1!}F^{'}(0) + \frac{x^2}{2!}F^{''}(0) + \frac{x^3}{3!}F^{'''}(0) + \cdots + \frac{x^n}{n!}F^{(n)}(0) + \cdots \quad (11)$$

The maximum point (which is unstable equilibrium point from the perspective of positive mass) is set as the origin of the coordinate (x=0), F(0)=0. When considering the case where displacement x is small, any higher degrees over can be ignored. The point that X=0 is the maximum point (the unstable equilibrium point), F(0) gets positive constant value. Therefore, F(0)=+k (constant) is set, it can be written as F(x)=+kx.

$$-m\ddot{x} = +kx \quad (12)$$

$$\ddot{x} + \omega_0^2 x = 0 \quad (13)$$

$(\omega_0^2 = \frac{k}{m})$

This form of differential equation is the same as that of particle which has positive mass. But we have to notice that positive mass carries out harmonic oscillation on a point of minimum value, whereas negative mass carries out harmonic oscillation on a point of maximum value.

As examined in the question of Harmonic oscillation, in case of positive mass, a point of minimum value which energy is the lowest is stable. However, in case of negative mass, stable equilibrium is a point of maximum value, not a point of minimum value. Therefore, negative mass is toward a point of maximum value to be stable, not a point of minimum value which energy is low.

2. The interpretation of negative energy level from the perspective of Quantum Mechanics

Hamiltonian H_- of negative mass (in harmonic oscillation)

$H_- = -\frac{1}{2}m\dot{x}^2 - \frac{1}{2}mw^2x^2$

$$= -\hbar w(\sqrt{\frac{mw}{2\hbar}}x + i\frac{P_+}{\sqrt{2m\hbar w}})(\sqrt{\frac{mw}{2\hbar}}x - i\frac{P_+}{\sqrt{2m\hbar w}}) \quad (14)$$

a (annihilation operator) and $a\dagger$ (creation operator) are defined

$$a = \sqrt{\frac{mw}{2\hbar}}x + i\frac{P_+}{\sqrt{2m\hbar w}} \quad (15)$$

$$a\dagger = \sqrt{\frac{mw}{2\hbar}}x - i\frac{P_+}{\sqrt{2m\hbar w}} \quad (16)$$

N$(a\dagger a)$ is

$N = a\dagger a = \frac{mw}{2\hbar}(x^2 + \frac{P_+^2}{m^2w^2} + \frac{i}{mw}[x, P_+])$

$$= \frac{1}{\hbar}[-\frac{H_-}{w}] - \frac{1}{2} \quad (17)$$

$$H_- = -\hbar w(N + \frac{1}{2}) \quad (18)$$

Eigen value of number operator N

If $N|n\rangle = n|n\rangle$, then

$$H_-|n\rangle = -hw(N + \frac{1}{2})|n\rangle \quad (19)$$

$$= -\hbar w(n + \frac{1}{2})|n\rangle \quad (20)$$

$$= E_-^n|n\rangle \quad (21)$$

Therefore,

$$E_-^n = -\hbar w(n + \frac{1}{2})(n = 0, 1, 2, 3, \cdots\cdots) \quad (22)$$

Ground state of negative mass is n=0 state. Eigen value is $E_-^0 = -\frac{1}{2}\hbar w$, first-excite state $E_-^1 = -\frac{3}{2}\hbar w$.

In the world of positive mass, ground state is a point that energy is low, but in case of negative mass, ground

state is a point that energy is the highest. Accordingly, in the world of negative mass, energy level is filled from the highest to the lowest, and stable state means the highest energy state, so the catastrophe to energy level of minus infinite never happens even if negative mass spontaneously emits energy.

3. The problem of transition from positive energy level to negative energy level

Since we do not know clearly about the characteristics of negative mass yet, we do not know whether transition of positive mass at the positive energy level to negative energy level is possible or not.

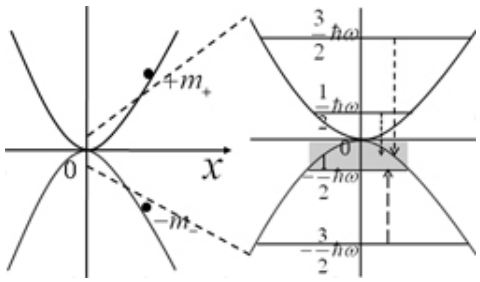

Figure 4: Transition to the minus energy level

However, for positive mass to enter the area of negative energy level, energy should have the negative value, and this means that it should have the characteristics of the negative mass.

When considering the process of entering the domain of negative energy level from positive energy level, it must pass through the domain between 0 and $-\frac{1}{2}\hbar\omega$. In case it follows the laws of negative mass because it's in the domain of negative energy, it cannot reach $-\frac{1}{2}\hbar\omega$,which is the first energy level of negative, because it is stable at the state of high energy, and it tries to have higher value of energy. It is because the energy level 0^- is much higher than the energy level $-\frac{1}{2}\hbar\omega$. That is to say that it shows possibility that the law of negative mass itself does not allow the situation where positive mass at the positive energy level succeed to the negative energy level. Even if it reaches $-\frac{1}{2}\hbar\omega$, the first energy level, at the negative energy level, it must follow the law of negative mass, it is stable at the state of high energy, and thus the PTEMI does not occur.

As we have examined above, the PTEMI does not occur, and thus positive mass and negative mass can exist in the same spacetime. This is a very important result because it means that negative mass and negative energy can exist stably in our universe.

This finding suggests that the PTEMI, which we have had for eighty years regardless of whether negative mass exists or not, does not occur, and it itself has important meaning. Thus, it needs to be reflected in the teachings that are being performed when explaining the solution to negative energy, which the relativistic energy eq. suggests.

III. The problem of nonobservance of negative mass and utilization of negative mass.

A. 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 born together at the beginning of universe, positive mass has attractive effect each other, so it forms star and galaxy structure13 now, and negative mass has repulsive effect each other, so it cannot form any structure, and may spread out uniformly in the whole area of universe.

Owing to the effect of negative mass and positive mass, negative mass was disappeared near massive positive mass structure (such as galaxy and galaxy cluster, etc.) after meeting positive mass, but negative mass which was born at the beginning of universe can still exist at the vacuum state out of general galaxy. Therefore, negative mass is not observed because negative mass was disappeared long time ago when forming galaxy.

2. The problem of nonobservance outside our galaxy.

Negative mass has repulsive effect each other, so they cannot make massive mass structure like star or galaxy. Therefore, it has not been observed even by observation of the universe all along.

B. Negative mass explains dark energy.

In 1998 year, observation by HSS (The High-z Supernova Search) team and SCP (Supernova Cosmology Project) team, they got a negative mass density from inspected field equation during 70years.

$\Omega_m = -0.38(\pm 0.22)$ [4]

$\Omega_m = -0.4(\pm 0.1)$ [15]

However, the two teams that judged that negative mass and negative energy level could not exist in our universe based on the PTEMI and nonobservance discarded the density of the negative mass, which was the result of the filed equation and rather revised the field equation, inserting the cosmological constant. [4], [15]

However, as this paper proves, the PTEMI does not occur, and consequently, negative mass and the state of negative energy can exist, the result of the field equation above rather becomes an indirect observance that suggests the existence of negative mass. Therefore, dark energy can be explained when negative mass exists [4], [15–17].

Moreover, we considered vacuum energy as the source of cosmological constant , but the current result of calculation shows , which is unprecedented even in the history

of Physics. Also, there exists a threat to conservation of energy that vacuum energy has. [17], [18]

C. Negative mass explains strange characteristics of dark matter.

Supposing that the essence of dark matter is negative mass, several characteristics of dark matter mentioned below can be explained validly.

1. The effect of centripetal force that dark matter creates [19–22]

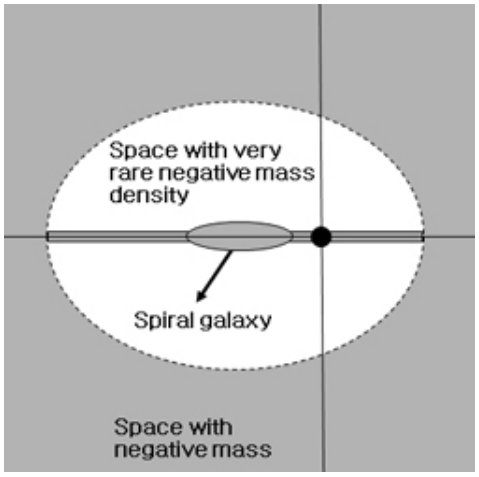

Figure 5: Structure of galaxy surrounded by negative mass that is distributed equally Negative masses are surrounding the galaxy that is consisted of positive mass. The white area is the area where negative mass barely exists.

Let's take a look at the effect of centripetal force of negative mass outside galaxy on mass M, which is located within the galaxy.

1) If we assume that the white empty space is full with negative mass and positive mass at the same density, White empty space $= 0 = (+mc^2) + (-mc^2) = 0$

2) Here negative mass is uniformly distributed over the whole area, so the effect of negative mass on mass m is 0.

3) Remaining positive mass is distributed over the white area at the density of negative mass, and the gravity that uniformly distributed positive mass works on positive mass m place on radius r is worked only by the distribution of mass within radius r because of shell theorem. Therefore, the effect of negative mass that remains out of galaxy can make it approximate to the gravity generated by the distribution of positive mass within the radius r in galaxy.

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

This effect suggests that the further from the center of the galaxy, the more mass effect exists and agrees with

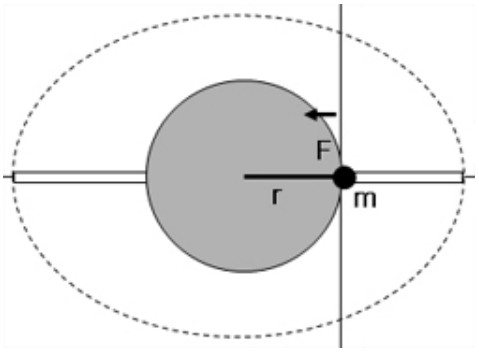

Figure 6: The gravitational effect from negative mass, which functions at mass m is equal to the gravitational effect from positive mass (same density to the negative mass density) within radius r.

the current situation where the further from the center of the galaxy, the more dark matter exists [20–22]. Above, the analysis was done while supposing the distribution of negative mass outside the galaxy as a uniform form. However, actually the galaxy consisted of positive mass affects gravitationally negative mass outside the galaxy, so the density of negative mass outside the galaxy is not uniform.

2. Dark matter that is almost uniformly distributed [21], [22]

By the repulsive effect among dark matter (negative mass), dark matter is distributed uniformly.

3. The problem of nonobservance of galaxy or cluster of galaxies consisted of dark matter [21], [22]

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

4. Low interaction among dark matter [21–23]

The repulsive gravity effect among dark matter is the cause.

5. The problem of nonobservance of dark matter

1) The fact that dark matter is unobserved earth or solar systems [24], [25].

2) Dark matter does not exist in the center of galaxy [26–28]. The result of observation that the black hole in the center of galaxy does not absorb dark matter and it will not absorb!

3) Dark matter does not exist in Galactic plane [29].

4) Dark matter does not exist in halo inside the galaxy [30].

Dark matter made of negative mass is usually distributed outside the galaxy, so it can explain the nonobservance of it inside the galaxy.

6. Dark matter becomes clustered around galaxy [21–23], [31].

According to The motions of negative mass and positive mass, that we have examined above, when the abso-

lute value of positive mass is bigger than that of negative mass, there exists the attractive effect between positive mass and negative mass, so the negative mass becomes clustered around the massive positive mass.

Currently, negative mass is distributed usually around outside the galaxy, the clustering phenomenon (or Gravitational Lens effect) of negative mass (dark matter) occurs in galaxy or at the level of cluster of galaxies.

The explanations above provide explanations about very strange characteristics related to those of dark matter. Dark matter that is consisted of negative mass usually spreads outside the galaxy, so it is observed that it becomes clustered [21–23], [31] around galaxy or clusters of galaxies that are consisted of positive mass. On the other hand, since it barely exists inside the galaxy, it doesnt show becoming clustered around Earth, or any objects in the solar system and galaxy [24–30], and yet, we can know that it still generates the effect of additional centripetal force on objects within the galaxy [19–22].

7. Why dark matter does not emit photon?

The current observation of dark matter requires explanation on important situations as the following. "Denial of the fundamental phenomenon of physics that absorbs or emits photons"

It is not the level that dark matter has not interacts electromagnetically because it is electrically neutral, but the observation result is the level that dark matter does not emits or absorbs photons.

Without giving that kind of characteristics of "the observation result that seems to be that it does not emit or absorb photons" from the first, can this kind of result be induced from other basic principle?

1) The process of negative mass emitting photon

$-E_- - h\nu < -E_-$

$-E_-$:Initial energy of negative mass ($E_- > 0$)

$h\nu$: Energy of photon

The relational expression above means that if negative mass emits photon (with positive energy), then the energy after emitting gets lower than the energy before emitting. Negative mass is stable at the state of high energy, so the voluntary transition that negative mass emits photon and succeeds to the lower energy level does not exist. Therefore, negative mass explains the result of the current observation that dark matter does not emit photon from the fundamental principle.

The explanation on why dark matter does not emit photon is enough with this. Below, more various situations are set-up.

2) The process of negative mass absorbing photon

Based on the inference so far, We think that there exists a process of negative mass absorbing photon.

$-E_- + h\nu > -E_-$

If negative mass absorbs photon, then it means that the energy after the absorption gets increased more than the energy before the absorption. However, since negative mass is usually distributed outside the galactic system, it does not interrupt path of light from a star in galaxy at all. Since it is distributed almost equally throughout the entire universe due to its repulsive characteristic as negative mass, it is deemed that instances of colliding with photon from other outside galaxy or absorbing photon are not many.

Also, if negative mass is reached a stable state, after moving for a long time to become stable, then it is assumed that the process of absorbing photon will occur under limited conditions as well. All kinds of restricting conditions (conservation conditions) exist in the process of becoming positive mass or succeeding to higher energy level because negative mass absorbed positive energy, then absorption of photon can be highly limited due to these kinds of restricting conditions.

3) The process of negative mass absorbing photon with negative energy

If negative mass and negative energy exist, then there is a possibility that photon with negative energy (tentative name: negaphoton) exists. To take a look at this instance,

$-E_- + (-h\nu) < -E_-$

It is the process of going to the lower energy level after negative mass absorbs negaphoton that the other negative mass emitted. As you can see from the observation of positive mass, there are more instances that this kind of excited state is usually in an unstable state [3]; therefore, negative mass would want to go to a stable state with high energy by re-emitting negaphoton. However, this kind of phenomenon, though it occurs, is difficult to observe because the energy is too small since it occurs individually outside the galaxy.

4) The process of negative mass emitting negaphoton

$-E_- - (-h\nu) > -E_-$

This is an instance when negative mass emits negaphoton and moves up to higher energy level.

Since the time has passed as much as the age of the universe after the creation of negative mass, negative mass has moved endlessly to become stable, and consequently, there is a possibility that most of negative mass reached the stable state.

Moreover, since negative mass is in the state of being equally distributed due to the repulsive gravitational effect, there is a possibility that it is at the most stable state, which it cannot go to the highest energy level in individual situation.

Therefore, the possibility that the process of emitting negaphoton for negative mass currently does not exist in large amounts is high.

5) The process of positive mass absorbing negaphoton

$+E_+ + (-h\nu) < +E_+$

In this instance, it is deemed that positive masses would lose kinetic energy or become the state of lower energy. However, in the early universe, the speed of par-

ticles was great, and also the possibility that the emission of photon and negaphoton was active is high. Therefore, if positive masses absorbed many negaphoton in the early universe, then there is a possibility that it lost mass and kinetic energy, and this effect could have a relation with the decelerating expansion of the universe for the first half time of the age of the universe.

IV. Discussion

Negative mass can explain several characteristics of dark matter and dark energy, which currently are the biggest problems in Cosmology. However, the qualitative explanation above is not yet proved through strict mathematical calculations and simulations.

As a result, the necessity of observation focusing on exact computation and detection of negative mass is stated.

Method of verification for negative mass:

A. Calculation of the centripetal force within the galaxy from the distribution of negative mass, corresponding to the size of dark energy

Currently, there are $\Omega_m = -0.38(\pm 0.22)$ and $\Omega_m = -0.4(\pm 0.1)$ values what HSS team and SCP team calculated in relation to size of negative mass corresponding with size of dark energy and there is $\Omega_m = -0.229$ that supposed the dark matter of WMAP to be all negative mass [32].

What we have to do now, is to induce rotation curve or the quantity of dark matters within the galaxy with above negative mass value.

Therefore, when centripetal force effect by density of this negative mass can explain rotation curve within the galaxy after setting density of negative mass outside of the galaxy as X times than positive masss, it would explain dark energy and dark matters at once through negative mass, thus proves that hypothesis is right. Things to consider here are the point that dark energy is an antigravity element and confronts the gravitational potential energy between negative mass and positive mass.

B. Simulation of the Bullet Cluster [23]

1) Positive mass (hot gas) and positive mass (hot gas) : attractive - It is shown that there is a gravitational pull between hot gases.

2) Negative mass (dark matter) and negative mass (dark matter) : repulsive - It does not show a massive structure that is only consisted of dark matter.

3) Massive positive mass (Galaxy Cluster) and negative mass (dark matter) : attractive Around a massive positive mass like galaxy, there exists a clustering of dark matter.

V. Conclusion

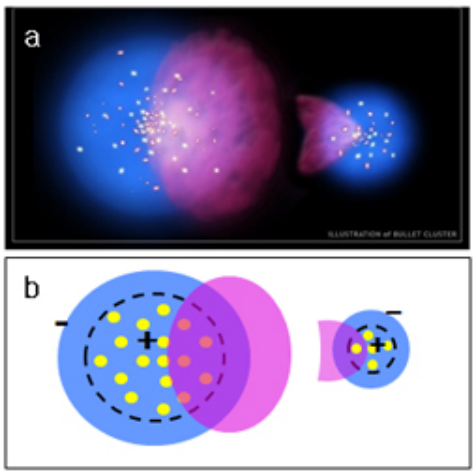

Figure 7: Simulation of the Bullet Cluster a. Ordinary matters (red color) are close to each other, and dark matters (blue color) are on the far side. b. Blue color is negative mass, yellow spot is galaxy.

The fundamental proposition SLES is an incomplete one, and it should be revised as, In case of positive mass, it is stable at the state of low energy, and in case of negative mass, it is stable at the state of high energy!

In the world of negative mass, it is stable at the state of high energy, so the PTEMI, which we have had for eighty years, does not occur, and therefore, negative mass can exist in our universe.

Moreover, negative mass provides explanations for the dark energy, which has antigravity element and is considered as the source of the universe expansion and acceleration, and also valid explanation for dark matter that generates the additional effect of centripetal force on objects within galaxy and shows to become clustered outside galaxy.

Therefore, we need to examine negative mass more seriously as a solution to dark matter and dark energy and do simulations.

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Supplementary Information

This thesis is an another version of thesis "Hypothesis of Dark Matter and Dark Energy with Negative Mass "(http://vixra.org/abs/0907.0015).