Is the State of Low Energy Stable? Negative Mass and Negative Energy

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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 this 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 essay, 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.

Basic Physical Principle : The State of Low Energy is Stable.

Modified Basic Physical Principle : Positive mass is stable at the state of low energy while negative mass is stable at the state of high energy.

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?

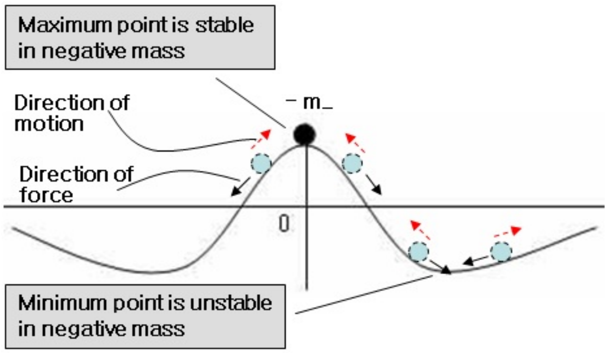


Figure 1: When there is negative mass in potential which has a point of maximum value and a point of minimum value.

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

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

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 $-\frac{1}{2}\hbar\omega$. 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 essay, 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.

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

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 consists of the following three items.

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

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

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

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

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

For example, when two pairs exist,

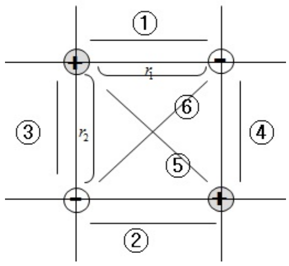


Figure 2: When two pair exist

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

Gravitational potential energy 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 gravitational potential energy can have various values (-, 0, +).

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.**

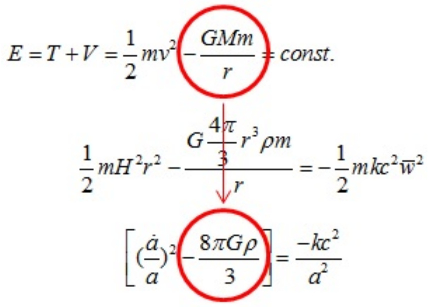
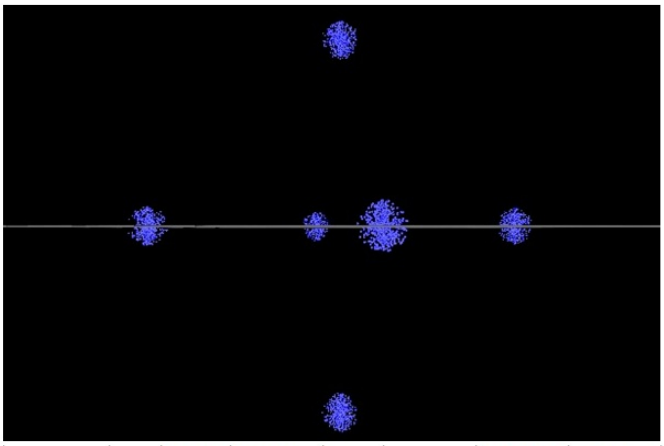


Figure 3: From the Friedmann equation, we judge the components of the universe by gravitational effect (or gravitational potential energy) rather than mass energy.



		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. (±1200,0,0), (0,±1200,0), (0,0,±1200), each 100. $-m_- =$ (-0.2 X 500) X 6 = - 600. Negative mass distribution : center(±1200,0,0), center(0,±1200,0), center(0,0,±1200), negative mass is spread within R=3-120, min. distance = 8. [14]

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.

Through the distribution of a negative mass and a positive mass when total mass energy is at the state of 0,(see to figure 3) 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 gravitational potential energy (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 gravitational potential energy which is 15 times more than the gravitational potential energy 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 3)

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.

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

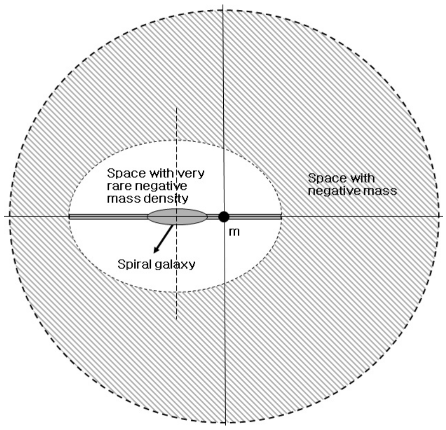


Figure 5: The structure of the galaxy surrounded by negative mass that is distributed equally. Negative mass is surrounding the galaxy that consists of positive mass. The white area is the area where negative mass almost does not exist.

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.

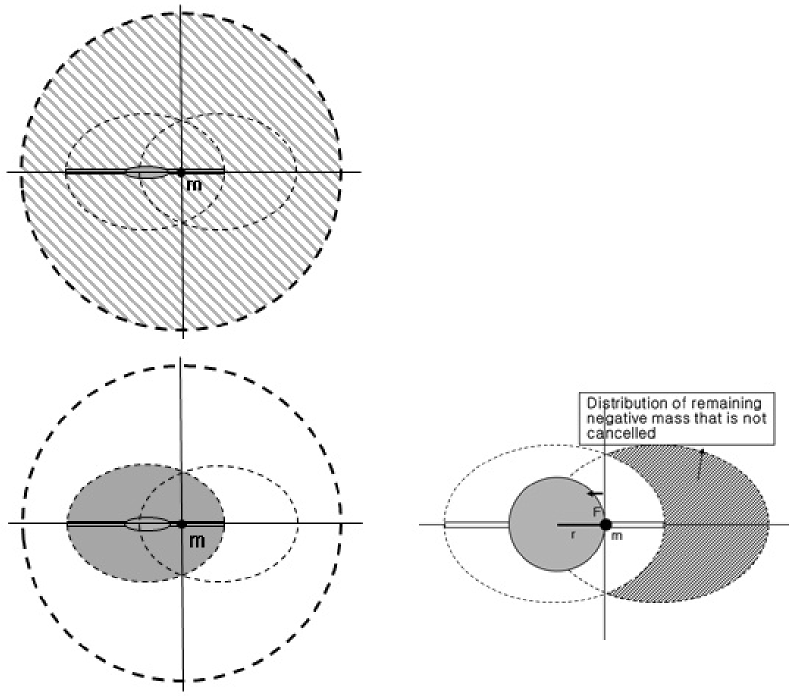


Figure 6: The effect of negative mass that remains outside of the galaxy can make it possible to be approximate to the gravity generated by the distribution of positive mass within the radius r in the galaxy.

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

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, gravitational potential energy 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.

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Supplementary Information

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