On Problems and Solutions of General Relativity (Commemoration of the 100th Anniversary of General Relativity)

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In commemoration of the 100th anniversary of general relativity, many others would look back on its history and achievements, so I will write mine focusing on the problems of general relativity and their solutions.

Pieces of writing hereunder are the rearrangement of my past idea from thesis [1] [2] and postings on my personal blog [3] and science community by focusing on the theme of problems and solutions of general relativity.

I. Several problems of general relativity

Since its publication [4], general theory of relativity has been numerously challenged but time-tested in the process through numerous experiments(Gravitational time dilation and frequency shift, Precession of apsides, Gravitational lensing...). [5] [6]

However, the possibility and demand for revised general relativity is also coming to the fore. This arises from its own problem of general relativity or is required from newly found observations. In my eyes, currently, there are three big problems with respect to general relativity.

1) Problems of integration with quantum mechanics and the case of a very big curvature in space-time [5] [7]

2) The theory includes the existence of singularity, which denies the application of general relativity itself, as a solution for field equation. [5]

3) Rising of the problems of dark energy and dark matter [8–13]

I would investigate these problems in reverse order and propose my ideas to work them out or solutions.

II. Problems of dark energy and dark matter

1. Rising of the problems of dark energy and dark matter

To explain the phenomena currently observed from the universe, we assume the need for something unknown called dark matter and dark energy. [8] [9] However, since its quantity is so great(95% level of total mass in the universe) [14] [15] but not detected from our surroundings, [16–18] opinions are coming forth that general relativity should be revised into other forms as to the outside of the solar system.

While the standard model makes up a whole system with its entirety tested through experiments, dark matter is expected not to belong to this standard model. [19] One of the ways to solve this problem is a revision of general relativity.

Accelerated expansion of the universe suggests the existence of new force similar to anti-gravity, which is a result different from the initial expectation of general relativity. [6]

Although general relativity may be able to explain the universe's accelerated expansion within its own system of theory by adding cosmological constant, [7] [8] [20] this can be essentially nothing but a makeshift for general relativity.

Besides, even though the cosmological constant has met the purpose as a makeshift to lengthen the life of general relativity, we still have not succeeded in explaining the origin of the cosmological constant. [6] [20]

It is obvious that dark matter and dark energy are an observation that must be explained by general relativity, so to explain it, many scholars in the mainstream system of physics are seeking to revise the general relativity. We call them MOND [21] or F(R) theory backers. [22]

2. Some ways to solve the problem of dark energy and dark matter [1] [2]

2-1. Understanding of the problem

Since dark matter and dark energy comes from Friedman equation that governs cosmic dynamics, so we need to look into this equation again.

Friedman equation can be induced from 00 component of field equations.

$$R_{00} - \frac{1}{2}g_{00}R = 8\pi G T_{00} \tag{1}$$

$$(\frac{\dot{a}}{a})^2 = \frac{8\pi G\rho}{3} \tag{2}$$

But we can also induce this from conservation of energy in classical mechanics, which helps capture the situation definitely.

$$E = T + V = \frac{1}{2}mv^2 - \frac{GMm}{r} - \boxed{\frac{1}{6}\Lambda mc^2r^2} = const.$$

$$v = \frac{dr}{dt} = Hr = HR\varpi$$

$$\cancel{\frac{1}{2}m\varpi^2}\left[\left(\frac{1}{R}\frac{dR}{dt}\right)^2 - \frac{8\pi G\rho}{3} - \boxed{\frac{1}{3}\Lambda c^2}\right]R^2 = \cancel{\frac{1}{2}m\varpi^2}\left[-kc^2\right]$$

Figure 1: The Friedmann equation can derive from field equation or mechanical energy conservation equation. We judge the components of the universe by gravitational effect (or gravitational potential energy) rather than mass energy.

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

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.

From the relations above, we become aware that existence of gravitational potential energy brings the corresponding energy density into being, assuming what ratio of gravitational potential energy means what ratio of energy density.

Such relationship suggests that with two more terms of gravitational potential energy corresponding to the current dark energy and dark matter, it could explain the problem of these two satisfactorily.

Now, where could we find the source of these two new gravitational potential energies?

2-2. Solution of the problem [1] [2]

2-2-1. Negative mass and negative energy

2-2-1-1. Necessity to introduce negative mass

Solution of a certain problem may be found within the system of theory but at times outside of the theory.

Let's consider the source of our cosmic energy regardless of dark matter and dark energy.

If the conservation of energy that "energy will be always conserved" is applied to the initial state of the universe, this gives rise to the question of "where the energy of our universe did come from?". The most natural answer to this question is the assumption that the energy itself was not something created and that zero-energy state went through phase transition keeping conservation of energy and generating negative and positive energy. Therefore, in order to offset the known positive energy of matter, negative energy(mass) is needed.

2-2-1-2. Main characteristics of negative mass

1) Negative mass has both negative inertial and gravitational mass. [23]

The motion characteristics of negative mass have been fully explained in the previous papers [23–26], so please refer to the paper and the following video. [26]

http://www.youtube.com/watch?v=MZtS7cBMIc4

One thing to note in the discussion is that the terms that have already been applied to positive masses can be confusing.

	Force	Motion	Active Mass
m_+ --r-- m_+	$F_{++} = -\frac{Gm_+m_+}{r^2}$ Attraction or attractive force	Attractive motion or attractive effect (decrease in distance)	$F = -\frac{Gm_+(\_)}{r^2}$ Attract
$-m_-$ --r-- $-m_-$	$F_{--} = -\frac{G(-m_-)(-m_-)}{r^2} = -\frac{Gm_-m_-}{r^2}$ Attraction or attractive force	Repulsive motion or repulsive effect (increase in distance)	$F = -\frac{G(-m_-)(\_)}{r^2}$ Repel
$-m_-$ --r-- m_+	$F_{-+} = -\frac{G(-m_-)(+m_+)}{r^2} = +\frac{Gm_-m_+}{r^2}$ Repulsion or repulsive force	$\lvert -m_- \rvert < m_+$: Attractive motion (decrease in dist.) $\lvert -m_- \rvert = m_+$: Runaway motion $\lvert -m_- \rvert > m_+$: Repulsive motion (increase in dist.)	

Figure 2: Different forms of explanation based on criteria(Force, Motion, Active Mass). Due to the negative inertial mass, the direction of force and motion changes. [27]

There are repulsive gravitational effects between negative masses.

One of problems regarding movement of negative mass, which researchers are likely to misunderstand is that if there are negative mass particles around the earth (or galaxy), large positive mass, they may not fly to the universe, but freely fall to the earth (or galaxy). Thus negative masses are clustered outside galaxy or cluster of galaxies. [1] [2]

2) Positive mass is stable at the low energy state, while the negative mass is stable at the high energy state. [1] [24]

One of physics' fundamental principles, "lower energy state is associated with stability" can be only applied to positive mass. However, both negative mass and negative energy level have been denied, as it has been wrongly applied to negative mass.

$$\vec{F} = -m_-\vec{a} \quad (m_- > 0) \tag{3}$$

$$\vec{a} = -\frac{\vec{F}}{m_-} \tag{4}$$

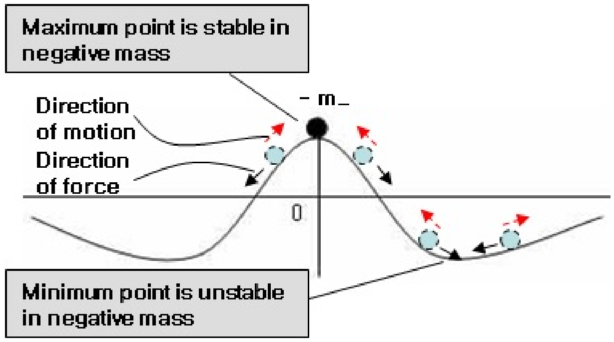

Figure 3: When there is negative mass in potential which has a point of maximum value and a point of minimum value.

When negative mass exists within potential with maximal and minimal points, different directions of force and acceleration should be considered for negative mass.

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. [24]

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. Due to this, "the problem of transition to minus infinite energy level" does not occur, therefore negative mass(energy) and positive mass(energy) can exist stably in our universe. [1] [2] [24]

2-2-2. False claims about negative mass [23] [28]

1) The vacuum instability problem is wrong. [1] [2]

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

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

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

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

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

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 universe. This is a very important result because it means that negative mass and negative energy can exist stably in our universe.

2) The runaway motion problem is wrong. [27]

Runaway motion is an argument that the two masses continue to accelerate, in an ideal situation where the negative mass and the positive mass are exactly the same. [23] Runaway motion is used as a rejection logic of negative mass because no large energy motion is observed. [29]

a) The difference in mass when creating the pair of negative mass and positive mass [1]

As a general conjecture, when positive and negative mass are born, the mass will be exactly the same, but this is wrong. There is at least a gravitational potential energy between the two particles.

In the process of the pair creation of electron and positron, the effect of electromagnetic potential energy could be the same because the two particles had the same kind of energy(electron : +, positron : +). Therefore, the two particles could have the same mass. However, in the process of the pair creation of negative and positive mass, the effect of gravitational potential energy is different because the two particles have different types of energy(negative mass : -, positive mass : +).

This gravitational potential energy has a positive value and exists in a system containing two objects or two objects. If you add or subtract potential energy in two cases(Pair creation of electron and positron, Pair creation of negative mass and positive mass), you can see that they are different.

$m_- > 0, m_+ > 0$

$$E_T = 0 = (+E) + (-E) = (+m_+c^2) + (-m_-c^2) + \frac{Gm_+m_-}{r} = 0 \tag{5}$$

$$m_- = (1 + \frac{Gm_-}{rc^2})m_+ \tag{6}$$

In case the negative mass and the positive mass are pair created in the vacuum, according to the Energy Conservation Law, there must be a mass difference between the negative mass and the positive mass. [1]

$$|-m_-| > m_+ \tag{7}$$

As described in the previous paper [1] [24], acceleration is determined by the size of the opponent's mass. If the absolute value of the negative mass is greater than the absolute value of the positive mass, there is a repulsive gravitational effect between the two. In this case, the acceleration of positive mass is greater. As time passes, the two masses become more and more distant. In other words, the ideal situation of pairing is broken. Because the accelerations are not the same and the distance of the pairing increases, the interaction of the other particles becomes involved. Therefore, runaway motion is not maintained. In the classical analysis, the larger the mass difference(The shorter the distance of a pair), the more easily the pairing breaks.

This logic may be used as a theoretical basis(energy conservation law, mass difference, repulsive gravitational effect) for the presence of two masses after pair creation without pair annihilation. Please watch($|-m_-| > m_+$ case) the linked video. [26]

b) There is a possibility that the gravitational potential energy will break the ideal situation.

Although the absolute values of the masses of two objects are exactly the same, there is a gravitational potential energy between them.

$$U = -\frac{G(+m)(-m)}{r} = +\frac{Gmm}{r} > 0 \tag{8}$$

This gravitational potential energy has a positive value and exists in a system containing two objects or two objects. And, since all energy is a source of gravity, the gravitational potential energy must also act gravity source.

Thus, these experiments indicate that gravitational energy gravitates in the normal way. [30]

That is, even if the masses of negative mass and positive mass are exactly the same, the gravitational potential energy between them breaks this ideal situation.

c) Since "runaway motion" assumes a very ideal situation, an unusual movement occurs, but in the real world, this ideal situation may be broken by external factors (forces or fields by other objects . . .)

d) The possibility that the pair creation of a mass of negative and positive occurred only in the early part of the universe.

In the present time, there is a possibility that there will be limited pair creation as fields(electromagnetic field, strong field, week field) exist.

3) The wheel problem is wrong. [27] [32]

Regarding the negative mass, the following argument has long been in the academic world. However, this claim is also completely wrong.

What happens if one attaches a negative and positive mass pair to the rim of a wheel? This is incompatible with general relativity, for the device gets more massive.

-Thomas Gold, *in Negative mass in general relativity* [31]

a) In terms of force

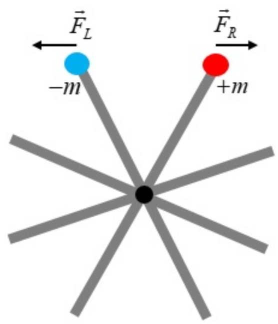

Figure 4: When the negative and positive mass is attached to the end of the wheel. In terms of force

There is a problem of "How do you combine a negative mass with a rod?" But let's assume that it is connected in any way. The forces acting on both rods are equal in magnitude and opposite directions.

$$\vec{F}_L = -\vec{F}_R \tag{9}$$

Therefore, the wheel does not rotate.

b) In terms of momentum

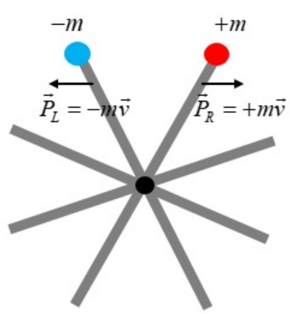

Figure 5: When the negative and positive mass is attached to the end of the wheel. In terms of momentum

In order for the wheel to move, momentum must be transmitted to the rod. But,

$$\vec{P}_L = -\vec{P}_R \tag{10}$$

The momentum transmitted to both rods is completely canceled. Therefore, the wheel does not rotate.
He should have thought that the momentum had to be transmitted in order for the wheel to rotate.

4) Spin-2 field problem is wrong.

Since the gravitational field is the spin-2 field, like charges attract and unlike charges repel. However, because negative mass repels each other, some argue that negative mass violates the results of quantum field theory. [28]

This argument is a simple mistake that arises from the misunderstanding of the form of force acting between negative masses and the effect of inertial masses having negative values. As shown in Figure 2, the forces acting between the negative masses are still attractive force.

5) Non-observation problem is wrong.

All new discoveries were called new discoveries because they were not found until then. Throughout the history of science, among the things that have not yet been discovered, new discoveries have had many examples. In other words, it does not guarantee that undiscovered findings of any physical object will be undiscovered in the future. The history of physics, and even the history of science.

And even if we find something, our existing knowledge either rejects this discovery or tries to interpret it only through existing ideas.

In 1998 observations, the first result of the Friedmann equation was negative mass density. But the researchers, who had difficulty accepting negative masses, modified the equation. And they argue that the accelerated expansion of the universe is evidence of the existence of a cosmological constant. [33] New ideas that challenge the paradigm are hardly subject to legitimate scientific review. In the process of discarding the negative mass that is the result of the field equation, it is assumed that the false claims listed above played a key role. Since the rejection logics for the negative mass are wrong, the negative mass model needs to be reviewed again.

From the second Friedmann equation or acceleration equation,

$$\frac{1}{R}(\frac{d^2R}{dt^2}) = -(\frac{4\pi G}{3})(\rho + 3P) \tag{11}$$

Since ρ is the energy density in the acceleration equation, the pressure term P also has a dimension of energy density(c=1). Current acceleration equation inevitably require negative (gravitational) mass density. Without negative (gravitational) mass density, it is impossible to create acceleration expansion. The mainstream produces acceleration expansion by setting the pressure of the cosmological constant or vacuum energy to $P = -\rho$.

However, the notion created by the mainstream has an inertial mass density of $+1(\rho)$, equivalent mass density of kinetic energy(or negative pressure) of -3(ρ), with gravitational mass density of -2(ρ). Not only different signs, but different values. It violates the principle of equivalence of inertial mass and gravitational mass, which is the basis of general relativity theory.

$$-2\rho = \rho + 3(-\rho) = -2\rho \tag{12}$$

a) Sign of the negative pressure [32]

In the acceleration equation, 3P has the idea of an equivalent mass density corresponding to the kinetic energy of the particle. So, assuming that the pressure P term has a negative energy density is same assuming that it has negative kinetic energy. In order to have negative kinetic energy, it must have negative inertial mass. But, because they assumed a positive inertial mass, it is a logical contradiction.

b) Size of the negative pressure [32]

In the ideal gas state equation, we obtain,

$$P = \frac{1}{3}(\frac{v^2}{c^2})\rho = \omega\rho \tag{13}$$

In the case of mater, $v \ll c$, $\omega = 0$, In the case of radiation, $v = c$, $\omega = \frac{1}{3}$

By the way, how can we physically create three times ω larger than light? How do we get the size 1 of $|\omega|$? If we assume an object with superluminal speed $\sqrt{3}c$, can we explain it? Well, we can avoid this problem by assuming that cosmological constant or vacuum energy does not apply to the results(ideal gas state eq.) obtained through physics. However, ideal gas state equation applies to "massless to infinite mass" particles, and the velocity ranges from "0 to c" are all included. If we seriously consider the physical presence of $P = -\rho = -3(\frac{1}{3}\rho)$, we will find that there is a serious problem.

The relation $P = -\rho$ obtained from thermodynamics is obtained from the assumption that the energy density is constant even when the space expands. This conclusion is only a conclusion obtained by assuming certain conditions hold, and may not guarantee the existence of a physical reality.

[(Simple) Negative mass model]
Inertial(Gravitational) mass density : -2(ρ),

[Mainstream model]
Inertial mass density : +1(ρ),
Equivalent mass density of kinetic energy(or pressure term) : -3(ρ)
Gravitational mass density : -2(ρ).

We have to know that not the field equation has disposed the negative mass, but our wrong stereotype disposed that negative mass.

2-2-3. Theoretical demonstration of constituent ratio of the universe by Pair Creation Model [2]

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

$$U_T = \sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i<j}(-\frac{G(-m_{-i})(-m_{-j})}{r_{--ij}}) + \sum_{i,j}(-\frac{G(-m_{-i})m_{+j}}{r_{-+ij}}) \tag{14}$$

$$U_T = \sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i<j}(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}) + \sum_{i,j}(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}) \tag{15}$$

$$U_T = U_{++} + U_{--} + U_{-+} \tag{16}$$

The present cosmological constant can be obtained by adding potential $U_\Lambda = -\frac{1}{6}\Lambda mc^2r^2$ to mechanical energy conservation equation. [6] Refer to figure 1. 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.(16)) into it.

If U_{++}, U_{--}, U_{-+} has a ratio(4.9% : 26.8% : 68.3%) between each other, maybe, we will estimate that ratio of energy density such as 4.9% : 26.8% : 68.3% exist. [2]

2-2-3-1. Total gravitational potential energy in the universe that consists of negative mass and positive mass, and dark Energy

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

Total gravitational potential energy U_T is as shown in equation (15). As we maintain that each gravitational potential energy corresponds to matter, dark matter, and dark energy, the following formula can be drawn.

$$\begin{aligned} U_T &= \sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i<j}(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}) + \sum_{i,j}(+\frac{Gm_{-i}m_{+j}}{r_{-+ij}}) && (17) \\ &= U_m + U_d + U_\Lambda && (18) \end{aligned}$$

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

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

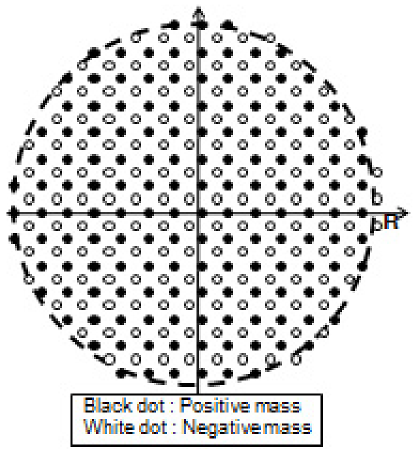

Figure 6: Universe where negative mass(energy) and positive mass(energy) are evenly distributed.

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 gravitational potential energy terms have negative values.

$$U_S = \sum_{i<j}(-\frac{Gm_{+i}m_{+j}}{r_{++ij}}) + \sum_{i<j}(-\frac{Gm_{-i}m_{-j}}{r_{--ij}}) + \sum_{i,j}(-\frac{Gm_{-i}m_{+j}}{r_{-+ij}}) \tag{19}$$

$$= U_m + U_d - U_\Lambda \tag{20}$$

$$= -\frac{3}{5}\frac{GM^2}{R} \tag{21}$$

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

$$U_m + U_d - U_\Lambda = -\frac{3}{5}\frac{GM_+{}^2}{R} - \frac{3}{5}\frac{GM_-{}^2}{R} - U_\Lambda = -\frac{3}{5}\frac{GM^2}{R} \tag{22}$$

$(M_+ = M_- \geq 0, M = M_+ + M_-)$

Therefore, it can be inferred that the dark energy itself will have the following forms.

$$U_\Lambda = +k_h(t)\frac{GM^2}{R} \tag{23}$$

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.

2-2-3-2. Current universe : If positive mass constitutes galaxy or cluster of galaxies and negative mass are completely distributed evenly [2]

$U_{++} = -\frac{3}{5}\frac{GM_+{}^2}{R}$ 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 gravitational potential energy between the sun and the earth is

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

$$U_T = U_S = U_{self-Sun} + U_{self-Earth} + U_{Sun-Earth} \tag{24}$$

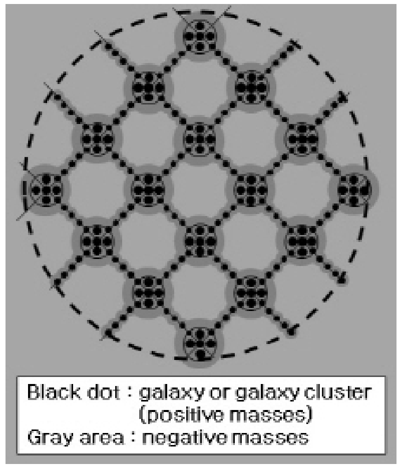

Figure 7: The current universe presumed in this model: Although the positive mass(black dot) constitute galaxy or cluster of galaxies and negative mass(gray) are almost evenly distributed in the entire universe, it is presumed that the density of negative mass(dark gray) near the galaxy would be higher than that of negative mass in the void area(gray), because negative mass receives attractive gravitational effect from large positive mass.

$$U_{Sun-Earth} = U_S - (U_{self-Sun} + U_{self-Earth}) \tag{25}$$

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 'gravitational potential energy between the sun and the earth'.

In other words, the gravitational potential energy of objects that have strong gravitational bonds between them, does not change. It means that the gravitational potential energy 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 gravitational potential energy terms.

$$U_{++} = U_m = -\frac{3}{5}\frac{G{M_+}^2}{R} - N(-\frac{3}{5}\frac{G{m_+}^2}{r_0}) = -\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] \tag{26}$$

*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,**

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

$$\frac{U_{--}}{U_{++}} = \frac{U_d}{U_m} = \frac{-\frac{3}{5}\frac{G{M_-}^2}{R}}{-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right]} = \frac{1}{1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}} = c \tag{28}$$

$$N(\frac{m_+}{M_+})^2\frac{R}{r_0} = 1 - \frac{1}{c} \tag{29}$$

$$N(\frac{{\rho_{m+}}^2{r_0}^5}{{\rho_{M+}}^2R^5}) = 1 - \frac{1}{c} \tag{30}$$

From observation: $c_{WMAP} = \frac{23.3}{4.6} \simeq 5.065$ [14], $\quad c_{Planck} = \frac{26.8}{4.9} \simeq 5.469$ [15]

Now, let's calculate dark energy:

If $U_S \approx -\frac{3}{5}\frac{GM^2}{R}$,
From the equation (21)(22), we get,

$$-\frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - \frac{3}{5}\frac{G{M_-}^2}{R} - U_\Lambda \approx -\frac{3}{5}\frac{GM^2}{R} \tag{31}$$

$$U_\Lambda \approx +\frac{3}{5}\frac{GM^2}{R} - \frac{3}{5}\frac{G{M_+}^2}{R}\left[1 - N(\frac{m_+}{M_+})^2\frac{R}{r_0}\right] - \frac{3}{5}\frac{G{M_-}^2}{R} \tag{32}$$

1) **WMAP:**

$$\begin{aligned} U_\Lambda &= +\frac{3}{5}\frac{G(2M_-)^2}{R} - \frac{3}{5}\frac{G{M_-}^2}{R}(\frac{1}{5.065}) - \frac{3}{5}\frac{G{M_-}^2}{R} \\ &= (4 - \frac{1}{5.065} - 1)\frac{3}{5}\frac{G{M_-}^2}{R} \\ &= (-2.803)U_d \end{aligned} \tag{33}$$

Therefore,

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.197 : -1 : +2.803 = 4.93\% : 25.00\% : 70.07\% \tag{34}$$

It's very close to observed WMAP value.

2) **Planck:**

$$\begin{aligned} U_\Lambda &= +\frac{3}{5}\frac{G(2M_-)^2}{R} - \frac{3}{5}\frac{G{M_-}^2}{R}(\frac{1}{5.469}) - \frac{3}{5}\frac{G{M_-}^2}{R} \\ &= (-2.817)(-\frac{3}{5}\frac{G{M_-}^2}{R}) \\ &= (-2.817)U_d \end{aligned} \tag{35}$$

Therefore,

$$U_{++} : U_{--} : U_{-+} = U_m : U_d : U_\Lambda = -0.183 : -1 : +2.817 = 4.58\% : 25.00\% : 70.43\% \tag{36}$$

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

Average of WMAP and Planck - Matter : Dark Matter : Dark Energy = 4.75% : 25.05% : 70.20%
Average of Pair Creation Model - Matter : Dark Matter : Dark Energy = 4.75% : 25.00% : 70.25%

We found the ratio above with Pair Creation Model for negative and positive masses, and the value being similar to the current cosmic observation suggests the need to review this model seriously.

2-2-3-3. Pair Creation Model with negative and positive masses [1] [2]

In the above process of finding the ratios of matter, dark matter and dark energy, I used very strong constraints.

1) The universe consists of negative mass(energy) and positive mass(energy), with the same size of them.

2) Matter, dark matter and dark energy correspond to the gravitational potential energy made by positive masses, negative masses, and between positive and negative masses, respectively.

3) We judge the components of the universe by gravitational effect rather than mass energy. If U_{++}, U_{--}, U_{-+} has a ratio(4.9% : 26.8% : 68.3%) between each other, maybe, we will estimate that ratio of energy density such as 4.9% : 26.8% : 68.3% exist.

This does not mean that 68.3% 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. [2] This discovery implies that our belief that size of gravitational effect and size of components of the universe would always 1:1 correspond was wrong. [2] [25]

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.

Trimming up the model, I can explain the current observations accurately. For details, see this thesis. [2]

2-2-4. Strengths of Pair Creation Model with negative and positive masses

2-2-4-1. Demands from an fundamental law

Pair Creation Model is the one essentially demanded from conservation of energy.

$$E_T = 0 = (+E) + (-E) = (\sum m_+ c^2) + (\sum -m_- c^2) + (\sum U) = 0 \tag{37}$$

Think that the universe started with a specific energy E_1 instead of zero energy. Logically, such universe would permit all real number times energy state of this specific energy value E_1 and eventually allow the possibility of the existence and logics of the universe that has an infinite number of different energy values.

However, "0" is a very special value, and the universe was born from absolutely nothing, in other words, zero energy state and the birth process implies that it is a phase transition of a zero energy state. This suggests that the law of conservation of energy applies for the birth of the universe and **the zero energy value is the demand and outcome of the law of conservation of energy.**

Therefore, if it is verified that this model is correct, then it can be seen as the verification of that multiverse and anthropic principle are incorrect. [33] [34]

2-2-4-2. Negative mass is a valid solution for the universe' accelerated expansion.

ΛCDM, has been gracefully accepted as our current standard model of cosmology. But neither Λ nor CDM has been successfully proven till now. [6] [35] [36] 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.

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 $\Lambda = 0$, $\Omega_M = -0.38(\pm 0.22)$ [10]

SCP(Supernova Cosmology Project) team : If $\Lambda = 0$, $\Omega_M = -0.4(\pm 0.1)$ [11]

Therefore, negative mass is a valid solution for the universe' accelerated expansion.

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. [10] [11]

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. [6] [20]

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

2-2-4-3. Explanation of the failing observation of dark matter on earth or in the solar system

Currently, we are failing to detect dark matter from the solar system or the earth. [16–18] Dark matter consisting of negative mass exists outside the galaxy structure with only gravitational effect within the structure. Therefore, this enables us to explain the current situation in which gravitational effect does exist but the substance is not detected.

2-2-4-4. Pair Creation Model coincides with the assumption that particles considered the origin of dark matter should not exist in the Standard Model.

Negative mass complies with conservation of energy or conservation of momentum, and exists outside of the standard model.

2-2-4-5. CCC(Cosmological Constant Coincidence) Problem [6]

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.

2-2-4-6. Explanation of Fine Tuning Problem

Pair creation model secures that cosmic curvature is close to 0.

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

2-2-5. Method to test Pair Creation Model

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. [36]

The reason why the entire explanation of ΛCDM at this point in time seems to be right is that the repulsive gravitation effect corresponding to Λ and the attractive gravitational effect 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). The negative mass(energy) is the object that satisfies energy conservation and should be an indispensable concept.

ΛCDM model expects that the ratio of matter and dark matter will be constant, [36] 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 will describe 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 estimated to continue to accelerate its expansion. However, gravitational potential energy 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 completely 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 $\frac{\Omega_d}{\Omega_m}(t)$ [2]

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.

2-2-6. Expansion of general relativity [2]

Field equation of the existing general relativity is a special case of that for Pair Creation Model, that is, a version when there exists only positive mass.

Einstein's field equation is given by :

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G T_{\mu\nu} \tag{38}$$

We need to frame a new Friedmann equation and field equation, 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.

$U_T = U_{++} + U_{--} + U_{-+}$

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(gravitational potential energy 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

$$G_{\mu\nu} = 8\pi G T_{\mu\nu} \tag{39}$$

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G({}^{++}T_{\mu\nu} + {}^{--}T_{\mu\nu} + {}^{-+}T_{\mu\nu}) \tag{40}$$

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

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G({}^{++}T_{\mu\nu}) \tag{41}$$

Thus, we get an Einstein's field equation.

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

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = 8\pi G({}^{++}T_{\mu\nu} + {}^{--}T_{\mu\nu} + {}^{-+}T_{\mu\nu}) \tag{42}$$

We need solve this new field 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 mass source).

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

We can get a very similar result with the ΛCDM model. Also, it has a better condition. gravitational potential energy U_{-+}, which belongs to this dark energy, has a positive value, and generates repulsive force. We can explain the basis for this term. It is positive gravitational potential energy.

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 gravitational potential energy)' and 'U_{--}(attractive gravitational potential energy)' that plays a role of Λ and CDM respectively, are added one by one separately.

III. The existence of singularity, which denies the application of general relativity itself, as a solution for field equations. [3]

1. Understanding of the problem : Generation of singularity [37]

Generally, stars are under gravitational contraction by their own gravity and it is known that if this is contracted within a certain radius (like Schwarzschild radius), it makes a black hole which even lights cannot escape from.

Since gravity is generally an attractive force, gravitational contraction continues to exist in the black hole, too. Thus, in the central part of black hole exists an area with infinite density of energy, which point we call singularity. [37]

Such singularity denies application of the existing laws of physics and it is unnatural for a certain substantial object to have infinite density of energy. Besides, such singularity has never been observed as substance but is just a mathematical result of general relativity, which is considered a defect or limit of the theory.

We assume that the solution for this singularity consists in quantum mechanics. Though exact explanation is not available because quantum gravity theory in integration of quantum mechanics and gravity has not been completed yet, [6] [7] we are looking for ways to avoid the problem of singularity by supposing the minimum size in the superstring theory. [38]

This writing will prove that an object of positive energy has the minimum size for its existence and that since this size is in proportion to that of energy, there is no singularity with infinite density.

2. Solution of the problem [3]

2-1. Gravitational potential energy with negative values

Many teachers in the school are teaching that gravitational potential energy is a hypothetical energy by which to set randomly reference point, explaining that "The infinite point" has just been set for convenience.

Consequently, the majority of people simply consider that gravitational potential energy is a hypothetical or potential energy to be eliminated by setting randomly reference point, not an object that has a fixed value or substance like mass energy.

2-1-1. Gravitational potential energy is an object that has a certain value at all spatial positions.

Let's consider the case below.

When m is situated at r and 2r, we can see that these two have difference in gravitational potential energy and total energy.

While a) has rest mass energy and gravitational potential energy at position r,

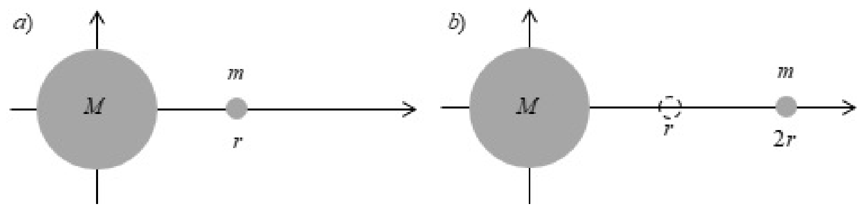

Figure 8: The mass (m) exists in a stationary state at the points r and 2r away from M.

In case of b), the m initially located at 2r becomes accelerated from a halting state to pass position r, Because b) has kinetic energy as well as rest mass energy and gravitational potential energy at position r. It seems obvious that this kinetic energy comes from gravitational potential energy, so gravitational potential energy is an object that has different values when r, a distance from gravitational source for all spatial positions, varies.

2-1-2. All energies are a gravitational source. [3]

We know that kinetic energy and thermal energy increase the mass of an object, and that these kinetic energy and thermal energy are also a kind of energy that plays the role as a gravitational source. [30] [39]

In general relativity, curvature in space-time is determined by the energy of its system while energy is a gravitational source. [5] [30]

If we set gravitational potential energy as such energy allowing randomly reference point, total energy of the system has an infinite number of values according to the reference point chosen by each of people who exists in the same inertial system at a single situation, while curvature of space-time must be changing numerously in real time by the threshold set optionally by people. This seems unnatural.

It seems logical that the curvature of space-time must have a single value at its same position and that the value of gravitational potential energy must also be in the form of a single value.

2-1-3. $U(r) = -\frac{GMm}{r}$ (except r=0) is considered to provide consequently the right explanation for all points

Teachers and professors have explained that it is alright to set the randomly reference point for gravitational potential energy because, since the variation of gravitational potential energy has caused kinetic change in the problem under review, there was no problem in dealing with only the variation of gravitational potential energy.

From the equation $K + U = const.$ we obtain such equation as $\Delta K = -\Delta U$, which can explain motion with variation, but this neither means that all observers in the same inertial system may set randomly reference point at random nor confirms that U is an object with an optional value.

Let's consider the following case that the value of gravitational potential energy has been fixed for the distance of 0 to infinity from gravitational source.

$$U(r) = -\frac{GMm}{r} \tag{43}$$

$$\Delta U = U_f - U_i = (-\frac{GMm}{r+h}) - (-\frac{GMm}{r}) = \frac{GMm}{r(r+h)}h \approx \frac{GMm}{r^2}h = mgh \tag{44}$$

Even though, as above, gravitational potential energy has the value of energy defined for r= 0 to r= infinity from gravitational source, we can obtain the right result in a problem in which its variation matters.

2-1-4. Effect of mass defect in atomic scale caused by binding energy

Equation of Coulomb potential energy($U = -\frac{kq_1q_2}{r}$), which is similar to gravitational potential energy, explains mass defect and energy level exactly against all positions of r, while we observe that the effect of mass defect occurs in as large the size as binding energy. [40]

Gravitational potential energy is another binding energy, which we should handle as substantial energy.

2-2. Gravitational self-energy or Gravitational binding energy [41]

The concept of gravitational self-energy is the total of gravitational potential energy possessed by a certain object M itself. Since a certain object M itself is a binding state of infinitesimal mass dM, it involves the existence of gravitational potential energy among these dMs and is the value of adding up these.

$M = \sum dM$

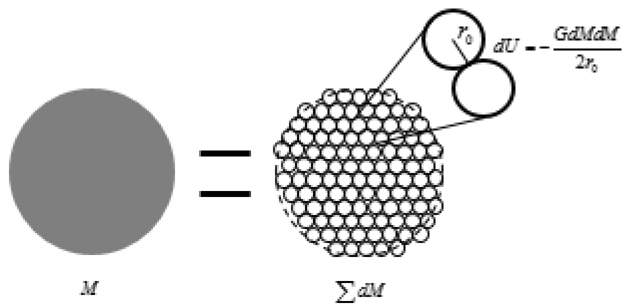

Figure 9: Since all mass M is a set of infinitesimal mass dMs and each dM is gravitational source, too, there exists gravitational potential energy among each of dMs. Generally, gravitational potential energy by infinitesimal mass that consists of an object itself is reflected on the mass of the object itself. Mass of an object measured from its outside corresponds to the value of dividing the total of all energy into c^2.

Gravitational self-energy or Gravitational binding energy($-U_{gs}$) in case of uniform density is given by:
$U_{gs} = -\frac{3}{5}\frac{GM^2}{R}$ (U_{gs} : gravitational self-energy)

2-3. For black hole or singularity, never fail to consider gravitational self-energy [3]

In the generality of cases, the value of gravitational self-energy is small enough to be negligible, compared to mass energy mc^2.

1)The earth's gravitational self-energy is roughly 4.6×10^{-10} times as large as the earth's rest mass energy.
2)The moon's gravitational self-energy is roughly 0.2×10^{-10} times as large as the moon's rest mass energy.

Therefore, in usual cases, $|U_{gs}| << Mc^2$, so generally, there was no need to consider gravitational self-energy.

Meanwhile, looking for the size in which gravitational self-energy becomes equal to rest mass energy by comparing both,

$$U_{gs} = |-\frac{3}{5}\frac{GM^2}{R_{gs}}| = Mc^2 \tag{45}$$

$$R_{gs} = \frac{3}{5}\frac{GM}{c^2} \tag{46}$$

This equation means that if mass is uniformly distributed within the radius R_{gs}, gravitational self-energy for such an object equals mass energy in size. So, in case of such an object, mass energy and gravitational self-energy can be completely offset while total energy is zero. Since total energy of such an object is 0, gravity exercised on another object outside is also 0.

Comparing R_{gs} with R_s, the radius of Schwarzschild black hole,

$$R_{gs} = \frac{3}{5}\frac{GM}{c^2} < R_s = \frac{2GM}{c^2} \tag{47}$$

$$R_{gs} = 0.3R_s \tag{48}$$

This means that there exists the point where gravitational self-energy becomes equal to mass energy within the radius of black hole, and that, supposing a uniform distribution, the value exists at the point $0.3R_s$, a 30% level of the black hole radius.

Even with kinetic energy and virial theorem applied only the radius diminishes as negative energy counterbalances positive energy, but no effects at all on this point: "There is a zone which cannot be compressed anymore due to the negative gravitational potential energy."

Considering the virial theorem,

$$R_{gs-vir} = \frac{1}{2}R_{gs} = 0.15R_s \tag{49}$$

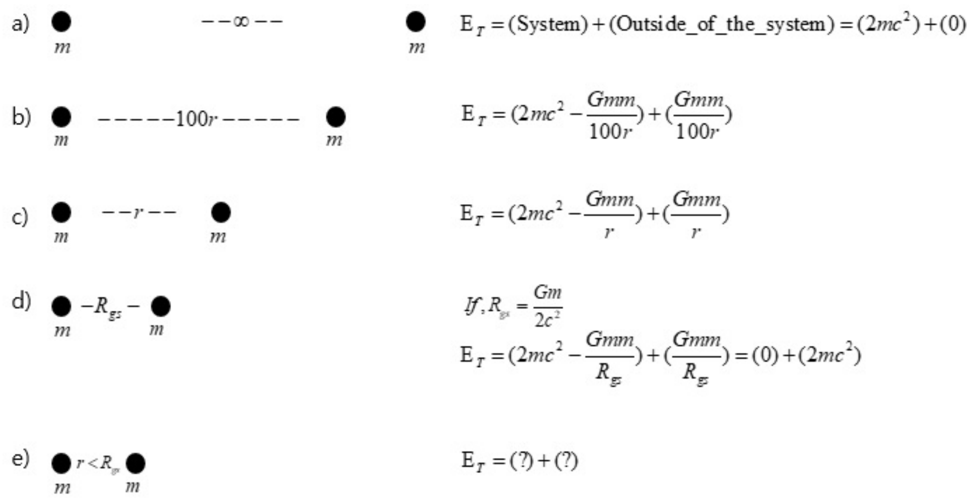

Figure 10: Explanation by the mass defect. Assumes a stationary state. if R is R_{gs}, the total energy of the system becomes 0 state. Now, in order for r to be smaller than R_{gs}, there must be energy release from the system to the outside of the system. In models that assume only positive energies, this state($r < R_{gs}$) must be prohibited because there is no positive energy to be removed from the system anymore. It is forbidden that the mass distribution of the system is within R_{gs}, and therefore no singular point is formed.

If we explain the phenomenon in terms of mass defect,

When the two particles are changed from the free state to the binded state, in order for the two particles to reach the binding state, the mass energy corresponding to the difference in the binding energy must be released to the outside of the system. We call it a mass defect. This suggests that the two particles do not reach a stable binding state without the mass defect (mass release to the outside of the system) corresponding to the difference in binding energies.

Now let's think about the inside of a black hole.

When the mass distribution inside the black hole is reduced from R_s to R_{gs}(or R_{gs-vir}), the energy must be released from the inside of the system to the outside of the system in order to reach this binding state. Here, the system refers to the mass distribution within the radius $0 \leq r \leq R_{gs}$ (or R_{gs-vir}).

At this time, the emitted energy does not go out of the black hole. This energy is distributed in the R_{gs}(or R_{gs-vir}) $< r \leq R_s$ region.

2-4. The inner mass sphere(area) of a black hole may not be a black hole state. [3]

Let's consider the situation in which a black hole may have just been formed. For simple analysis, assume a uniform mass distribution.

$$R_S = \frac{2GM_S}{c^2} \tag{50}$$

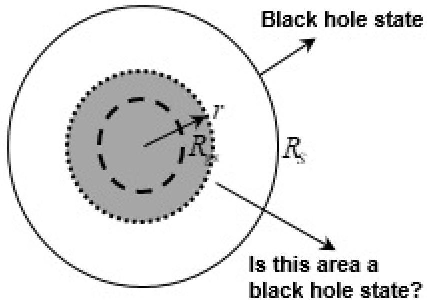

Figure 11: When a black hole is formed, the inner mass sphere(area) is not a black hole state. Thus, during the gravitational contraction process, the inner mass sphere(area) emits energy.

$$M_S = \frac{R_S c^2}{2G} \tag{51}$$

Now let's consider the mass within the inside shell.

$$M(r) = \frac{4\pi}{3} r^3 \rho \tag{52}$$

When the inner mass sphere(area) forms a black hole, let's look at the size of the mass distribution.

$$R_{S-M(r)} = \frac{2GM(r)}{c^2} = (\frac{r}{R_S})^3 R_S \tag{53}$$

For example, in order for the mass within the $r = \frac{1}{2}R_S$ shell to become a black hole, the Schwarzschild radius must be $R_{S-M(r)} = \frac{1}{8}R_S$. Mass density should be compressed 64 times. The point is, when a black hole is formed, the inner mass sphere(area) is not a black hole state. Therefore, the key point is that the inner mass sphere(area) will have an energy release during the gravitational contraction. At this point, we can consider the virial theorem.

2-5. Black hole doesn't have singularity. [3]

From the equation above, even if some particle comes into the radius of black hole, it is not a fact that it contracts itself infinitely to the point R=0. From the point R_{gs}, gravity is 0, and when it enters into the area of R_{gs}, total energy within R_{gs} region corresponds to negative values enabling antigravity to exist.

This $0.3R_s$ region comes to exert repulsive effects of gravity on the particles outside of it, therefore it interrupting the formation of singularity at the near the area r=0.

However, it still can perform the function as black hole because R_{gs} is only 30% of R_s with a large difference in volume and, comparing total mass, it still can correspond to a very large quantity of mass. Therefore, it still can perform the function as black hole on the objects outside of R_s.

If you have only the concept of positive energy, please refer to the following explanation.

From the point of view of mass defect, $r = R_{gs}$ is the point where the total energy of the system is zero. For the system to compress more than this point, there must be an positive energy release from the system. However, since the total energy of the system is zero, there is no positive energy that the system can release. Therefore, the system cannot be more compressed than $r = R_{gs}$. So black hole doesn't have singularity.

There are a few interesting cases here:

1)For case of forming black hole and then bursting

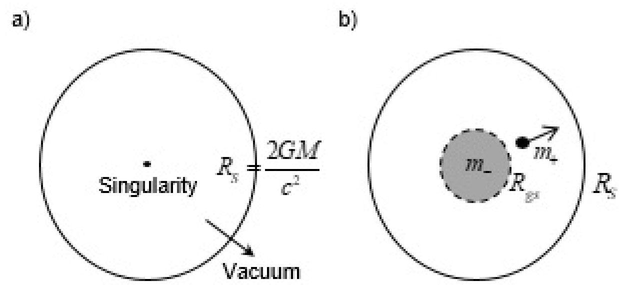

Figure 12: Considering gravitational potential energy for black hole, the area of within R_{gs} has gravitational self-energy of negative value, which is larger than mass energy of positive value. If r is less than R_{gs}, this area becomes negative energy(mass) state. There is a repulsive gravitational effect between the negative masses, which causes it to expand again. This area(within R_{gs}) exercises antigravity on all particles entering this area anew, and accordingly prevents all masses from gathering to r=0.

In the process of a star's gravitational contraction (or collapse), matters outside the radius of black hole flows inside black hole, where even if these particles enter inside the event horizon of black hole, velocity vector still has $-\hat{r}$ direction.

Thus, it can occur that these particles reach the area of R_{gs} and then pass over it.

On the above, situation of mass in uniform distribution was considered but for the mass not uniform in distribution, or in case of central density being much higher, these would expand themselves again. In some cases, they may pop out of the black hole. Maybe, it can be a solution to the problem of gamma-ray arising from the merger of the black holes. [42]

If a situation where R_{gs} becomes bigger than the minimum radius of the Kerr black hole occurs due to the particles absorbed form the outside, then it is possible for energy(and particles) to escape from the inside of the black hole.

2)For case of particles becoming stable while vibrating inside black hole

By locking horns between gravitational self-energy and mass energy, particles inside black hole or distribution of energy can be stabilized.

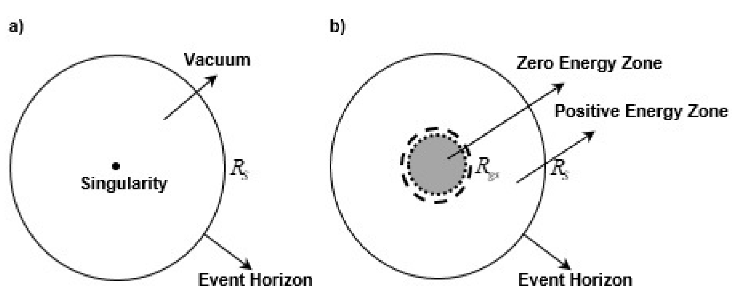

Figure 13: Internal structure of the black hole. a)Existing model b)New model. If, over time, the black hole stabilizes, **the black hole does not have a singularity in the center, but it has a zero energy zone.**

3)The analysis above is also applicable to birth of the universe.

Birth of high-density energy in such an area of Planck scale simply means that negative gravitational self-energy is larger than the mass energy of matter. So it generates repulsive effect and should result in cosmic expansion.

It can explain the reasons for expansion in high-density state in which gets over the density of black hole in the beginning of the universe, and expansion immediately after cosmic birth.

2-6. The minimal size of existence [3]

Differential and integral concepts we have acquired and used in mathematics and physics comprise the idea that an object can be considered "a set of some infinitesimals."

[**Existence = the sum of infinitesimal existences composing an existence**]

A single mass M for some object means that it can be expressed as $M = \sum dM$ and, for energy, $E = \sum dE$. The same goes for elementary particles, which can be considered a set of dMs, the infinitesimal mass.

The equation($R_{gs} = \frac{3}{5}\frac{GM}{c^2}$) above means that if infinitesimal masses are uniformly distributed within the radius R_{gs}, the size of negative-value binding energy becomes equal to that of mass energy. This can be the same that the rest mass, which used to be free for the mass defect effect caused by binding energy, has all disappeared.

This means the total energy value representing "some existence" coming to 0 and "extinction of the existence (with positive energy)". **Therefore, R_{gs} is considered to act as "the minimal radius" or "a bottom line" of existence with some positive energy.**

For case of proton,

$$R_{gs} = \frac{3}{5}\frac{GM}{c^2} = 7.457 \times 10^{-55}[m] \tag{54}$$

Currently, the size of proton is about $10^{-15}m$, which isn't against the assumption of this model

2-7. Expansion of general relativity [3]

2-7-1. In all existing solutions, the mass term M must be replaced by $(M - M_{gs})$.

We can solve the problem of singularity by separating the term($-M_{gs} = \frac{U_{gs}}{c^2}$) of gravitational self-energy from mass and including it in the solutions of field equation.

$M \rightarrow (M) + (-M_{gs})$, $-M_{gs}$ is the equivalent mass of gravitational self-energy. In all existing solutions(Schwarzschild, Kerr, Reissner-Nordström, ...), the mass term M must be replaced by $(M - M_{gs})$.

For example, Schwarzschild solution is,

$$ds^2 = -(1 - \frac{2GM}{c^2 r})c^2dt^2 + \frac{1}{(1 - \frac{2GM}{c^2 r})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{55}$$

Schwarzschild-Choi solution is

$$ds^2 = -(1 - \frac{2G(M - M_{gs})}{c^2 r})c^2dt^2 + \frac{1}{(1 - \frac{2G(M-M_{gs})}{c^2 r})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{56}$$

For the sphere with uniform density,

$$-M_{gs} = -\frac{3}{5}\frac{GM^2}{Rc^2} \tag{57}$$

1) If $M \gg |-M_{gs}|$, in other words if $r \gg R_S$, we get the Schwarzschild solution.
2) If $M = M_{gs}$,

$$ds^2 = -c^2dt^2 + dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{58}$$

3) If $M \ll M_{gs}$, in other words if $0 \leq r \ll R_{gs}$,

$$ds^2 \simeq -(1+\frac{2GM_{gs}}{c^2 r})c^2dt^2 + \frac{1}{(1+\frac{2GM_{gs}}{c^2 r})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{59}$$

i) $r \geq R$

$$ds^2 \simeq -(1+\frac{6G^2M^2}{5c^4Rr})c^2dt^2 + \frac{1}{(1+\frac{6G^2M^2}{5c^4Rr})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{60}$$

ii) $0 \leq r < R$

The area of within R_{gs} has gravitational self-energy of negative value, which is larger than mass energy of positive value. This area(within R_{gs}) exercises antigravity on all particles entering this area anew, and accordingly prevents all masses from gathering to r=0. Besides, negative mass has gravitation effect which is repulsive to each other. Therefore, we can assume that $-M_{gs}$ is almost evenly distributed. Therefore ρ_{gs} is constant. And we must consider the Shell Theorem.

$$-M_{gs} = -\frac{4\pi r^3}{3}\rho_{gs} \tag{61}$$

$$(1+\frac{2GM_{gs}}{c^2 r}) = 1 + \frac{2G(\frac{4\pi}{3}r^3\rho_{gs})}{c^2 r} = 1 + \frac{8\pi G\rho_{gs}r^2}{3c^2} \tag{62}$$

$$ds^2 \simeq -(1+\frac{8\pi G\rho_{gs}r^2}{3c^2})c^2dt^2 + \frac{1}{(1+\frac{8\pi G\rho_{gs}r^2}{3c^2})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{63}$$

If $r \to 0$,

$$ds^2 \simeq -c^2dt^2 + dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{64}$$

There is no singularity.

In practice, gravitational collapse must be stopped at the point where $M_{shell} = M_{shell-gs}$.

For Schwarzschild black hole, the Kretschmann scalar is,

$$R^{\mu\nu\rho\sigma}R_{\mu\nu\rho\sigma} = \frac{48G^2M^2}{c^4r^6} \tag{65}$$

In the preexisting model, if $r \to 0$, it does diverse.

However, this model is

$$R^{\mu\nu\rho\sigma}R_{\mu\nu\rho\sigma} = \frac{48G^2(M-M_{gs})^2}{c^4r^6} \approx \frac{48G^2(-M_{gs})^2}{c^4r^6} = \frac{(16\pi G\rho_{gs})^2}{3c^4} \tag{66}$$

If $r \to 0$, it does not diverge.

If, after the formation of a black hole, it has been stabilized for a long time, the model of Fig.13 should be taken into account. The black hole does not have a singularity in the center, but it has a zero energy zone(Areas with zero total energy.).

2-7-2. Gravitational self-energy can provide the concept of minimal size, one of the reasons for introducing string theory.

In quantum mechanics we could think of De Broglie's matter wave theory about length of some objects. However this formula does restrict the upper limit of velocity to c, but does not have the upper limit for mass. In other words this implies there is no lower limit of wavelength and it can go to 0 in quantum mechanics. It's the same with Heisenberg's Uncertainty Principle.

Furthermore, 0.02 milligram of Planck mass($m_p = \sqrt{\frac{c\hbar}{G}}$) they introduced is not even the size for the role of upper or lower limit among "$0 \sim \infty$". Since Planck mass cannot perform a role as the upper limit, Planck length, inversely related to the Planck mass, cannot do a role of lower limit either.

Planck mass and length means that "within such a size we should consider the quantum mechanical effects." but does not indicate "no more or no less can exist."

To remove singularity, considering gravitational self-energy is only enough without need to assume some minimal unit like a string. [38] Thus, the existing relations need to be transformed so that they may include the minimal length by dint of gravitational self-energy.

$$\Delta x \sim \frac{\hbar}{\Delta p} \tag{67}$$

$$\Delta x \sim \frac{\hbar}{\Delta p} + R_{gs} \geq \frac{3}{5}\frac{GM}{c^2} = \frac{3}{5}\frac{GE}{c^4} \tag{68}$$

Since the increase of momentum is put into the increase of energy and mass, Δx cannot go to 0. Therefore, we can introduce the minimal length naturally and work out the problems of singularity or infinity.

IV. Integration with quantum mechanics and a very large curvature in space-time

To solve this problem, we must reject the error originating with Bohr and start from the fact that the XXX theory is not beautiful. Specifically, $\sim \sim$

Ouch, it's time to go fry chicken.
Next time for the remainder

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