Hypothesis of dark matter and dark energy with minus mass

Hyoyoung Choi

In 1998 year, observation by The High-z Supernova Search team, if the cosmological constant is 0, $\Omega_M = -0.38(\pm 0.22)$. The quantity of the matter couldn't be negative value, so as far as we know, the value is trashed away. We have to know that not the field equation has disposed the value, but our thought disposed that value. In the world of plus mass, ground state is a point that energy is low, but in case of minus mass, ground state is a point that energy is the highest. Accordingly, in the world of minus 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 -∞ never happens even if minus mass spontaneously emits energy. Assuming that minus mass exists, Newton's Law of motion was derived in between minus and plus masses and also between minus and minus masses. Also, explanation on how minus masses will be distributed in the current state of space with Newton' Law of motion. As for dark matters and dark energy, minus mass can produce an additional centripetal force in the galaxy or galaxy cluster, which supports the dark matter, while the plus mass can emerge repulsive effects that accelerate the inflation direction and a qualitative interpretation could be possibly made on dark energy from minus mass. As a method for proving the existence of minus mass, an explanation on the revolution velocity of the galaxy through minus mass has been presented. In this process, the existence of spherical mass distribution was given; furthermore, explanation was done using this, to show observation results where dark matter effect through minus mass is proportional to distance r. If Ω_M is -0.38, universe's age is 14.225 Gyr. It is in the range estimated by other observations. Assuming that minus mass exists, it satisfies the various problems that previous dark matter and energy possess, such as, centripetal force effects of galaxy and galaxy clusters from previous dark matters, mass effects that is proportional to the distance r, repulsive force needed for expantion, dark energy that has plus values, low interaction between dark matter when collision occurs between dark matter and deceleration expansion and acceleration expansion of universe and formation of void and possibility to explain mechanism of inflation and difficulty in observation. As a result, the necessity of observation focusing on exact computation and detection of minus mass is stated.

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Email : hbar108@naver.com

I. Introduction

Now the observation is a very important issue, and seems to determine everything in quantum mechanics, but the observation is not to determine existence and nonexistence, it is just local evidence of existence and nonexistence, and the thing that determines existence and nonexistence in nature is all sorts of physical laws, not observation.

It is necessary to watch carefully the fact that all sort of physical laws such as Law of energy conservation or Law of conservation of momentum do not deny minus mass. [1] All sorts of physical laws do not deny them, thus minus mass can exist!

If we consider the situation of antiparticle and antimatter, we can know they exist, although they are not observed in common situation. We have must explain the reason why they are not easily observed in common situation by their motion or characteristics, suggest explanation of existing phenomenon, and new prediction with their characteristics, and inspect it with observation.

With the assumption that minus mass exists, in the text, the researcher tries to examine motion of minus mass and plus mass, and motion of minus mass and minus mass, and to suggest that minus mass can provide proper description of dark matter and dark energy.

Most of people have strong aversion of minus mass, but no law of physics says there is only plus mass in nature, and we think that we feel as if our thought of mass, namely mass that is the a synonym for the fact something exists denies negative value. However, negative charge and positive charge suggest that "something exists" does not mean plus value only. The great achievement of physics in theory of relativity and quantum mechanics request us to review the previous thought of physical quantities.

II. Newton's law of motion of minus mass

When an object with mass of +m1 is away from an object with mass of +m2 by distance r, the force worked between two objects is described as following type.

$$\vec{F} = -G\frac{m_1 m_2}{r^2}\hat{r} \tag{1}$$

When an object with mass of $-m_1$ is away from an object with mass of $-m_2$ by distance r, what type does the force worked between two objects have?

Many people think the force decides motion of object in gravity, but actually the acceleration decides the motion of object in gravity, and also plays a role of deciding the moving direction of object which is at the state of stop.

We can set up following dynamic equation to describe the motion of object. That is, the gravity created on mass $m_1$by mass m_2 is expressed as follows:

$$\vec{F_1} = m_1\vec{a}_1 = -G\frac{m_1 m_2}{r^2}\hat{r} \tag{2}$$

$$m_1\vec{a}_1 = -G\frac{m_1 m_2}{r^2}\hat{r} \tag{3}$$

$$\vec{a}_1 = -G\frac{m_2}{r^2}\hat{r} \tag{4}$$

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

1.The law of motion of plus mass and plus mass

Figure 1: Plus mass $+m_1$ and plus mass $+m_2$ (initial velocity =0, $m_1 > 0$, $m_2 > 0$)

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

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

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

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

Plus mass and Plus mass : The force worked between plus mass is attraction, and two objects move toward the center of mass. The force is attraction, thus their potential energy has minus value. The direction of acceleration is in the direction of $-\hat{r}$, so the distance between two objects are reduced gradually.

2.The law of motion of minus mass and plus mass

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

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

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

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

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

Minus mass and Plus mass : Minus mass is accelerated in the direction of plus mass, and plus mass is accelerated in the direction to be far away from minus mass.

The direction of acceleration a1 worked on minus 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 plus mass $+m_2$ is $+\hat{r}$, so plus mass $+m_2$ is accelerated in the direction that distance r increases, namely the direction of being far away from minus mass.

If the absolute value of plus mass is bigger than that of minus mass, they will meet within finite time(attractive effect), and if the absolute value of plus mass is smaller than that of minus 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 plus value.

3.The law of motion of minus mass and minus mass

Figure 3: minus mass -m_1 and minus mass -m_2 (initial velocity =0, $m_1 > 0$, $m_2 > 0$)

$$-m_1\vec{a}_1 = -G\frac{(-m_1)(-m_2)}{r^2}\hat{r} \tag{13}$$

$$\vec{a}_1 = +G\frac{m_2}{r^2}\hat{r} \tag{14}$$

$$-m_2\vec{a}_2 = -G\frac{(-m_1)(-m_2)}{r^2}\hat{r} \tag{15}$$

$$\vec{a}_2 = +G\frac{m_1}{r^2}\hat{r} \tag{16}$$

Minus mass and Minus mass: Both two objects are accelerated in the direction of $+\hat{r}$ which extends radius r, so as time passes, the distance between them is greater than initially given condition, and the force between them is attraction, but the effect is repulsive. The force is attraction($-Gm1m2/r^2$), thus the potential energy between them has minus value.

4.Minus mass cannot form the structure greater than atom

As examined the equation of motion for minus mass, it is marked in form of $F = -ma(m > 0)$, when attraction is applied together with nuclear force(when usually nuclear force is attraction, but has the form of repulsive core [2]), and assuming nuclear force has the form of $\vec{F} = -Q(r)\hat{r}$, Q(r) is the positive function of distance r, thus nuclear force is in the form of attraction worked in the direction of -$\hat{r}$. Here, for the force worked on minus mass m,

$$\vec{F} = -m\vec{a} = -Q(r)\hat{r} \tag{17}$$

$$\vec{a} = \frac{Q(r)}{m}\hat{r} \tag{18}$$

the term of acceleration is plus, so the effect of increasing radius r, namely repulsive effect appears. This means that minus mass cannot form the structure like atom because nuclear force is not binding minus mass when it is applied to minus mass.

Additionally, for the problem of mesons that mediates nuclear force or weak interaction, if there is no meson that delivers strong interaction or weak interaction, it is doubtful if strong interaction or weak interaction can be worked or not. For example, nucleon must have internal structure including meson or quark, but in case of minus mass, nuclear force is repulsive, so it cannot have the internal structure of nucleon from the beginning. That is, there is a great possibility that minus mass cannot include meson or quark which has minus mass in nucleus.

The fact that it cannot make nucleon means that it is impossible to form massive mass structure like a star in addition to atomic structure and molecular structure. This provides proper explanation of the fact that minus mass is not seen as it has visible massive mass structure. Also generally it satisfies the nonbaryonic [3] matters required for dark matter.

If minus mass was born at the beginning of universe, there is higher possibility that it exists until now as a certain basic state born at the beginning of universe, and that it does not have strong interaction like nuclear force, weak interaction, and electromagnetic interaction. This point is keeping with current characteristics required for dark matter.

5.Harmonic oscillation of minus mass [1]

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 minus mass. That is, if there is minus mass and minus energy level, minus mass spontaneously emits energy to be stable, and goes to energy state of -∞, so finally it is confronted by catastrophe. Is it right?

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

We can get an answer, if we examine Harmonic oscillation.

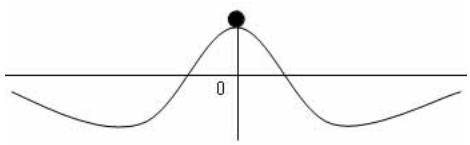

Figure 4: When there is minus mass in potential which has a point of maximum value and a point of minimum value.

We begin by considering the oscillatory motion of a particle that is constrained to move in one dimension. We assume that there exists a position of unstable equilibrium for the particle and we designate this point as the origin. Restoring force is in general some complicated function of the displacement and perhaps of the particles velocity or even of some higher time derivative of the position coordinate.

We consider here only case in which the restoring force F is a function only of the displacement

F(x) can be expanded in a Taylor series,

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

$$+\frac{x^n}{n!}F^{(n)}(0) + \cdots \tag{19}$$

Since the origin is defined to be the equilibrium point, F(0) must vanish, Then, if we confine our attention to displacements of the particle that are sufficiently small, we can neglect all terms involving x^2 and higher powers of x. We have, therefore, the approximate relation

$$F(x) = +kx \tag{20}$$

The force is alaways the opposite directed toward the unstable equilibrium position(the origin), the derivative $F^{'}(0)$ is positive and therefore k is a positive constant.

$$-m\ddot{x} = +kx \tag{21}$$

$$\ddot{x} + \omega_0^2 x = 0 \tag{22}$$

$$(\omega_0^2 = \frac{k}{m}) \tag{23}$$

This form of differential equation is the same as that of particle which has plus mass. But we have to notice that plus mass carries out harmonic oscillation on a point of minimum value, whereas minus mass carries out harmonic oscillation on a point of maximum value. Additionally, restoring force is +kx at this time.

$$\vec{F} = -\nabla U \tag{24}$$

$$U = -\frac{1}{2}kx^2 \tag{25}$$

$$E_- = T + U = -\frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^2 = -\frac{1}{2}m\omega_0^2 A^2 \tag{26}$$

In phase space

$$\frac{x^2}{(\frac{-2E_-}{k})} + \frac{p^2}{(-2mE_-)} = 1 \tag{27}$$

This equation is ellipses equation, because total energy $E_- < 0$

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

In the world of plus mass, ground state is a point that energy is low, but in case of minus mass, ground state is a point that energy is the highest. Accordingly, in the world of minus 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 -∞ never happens even if minus mass spontaneously emits energy.

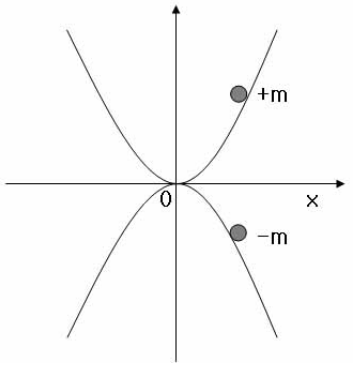

Figure 5: Harmonic oscillation of minus mass

In harmonic oscillation of minus mass

$$E_- = -\frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^2 = -E_+ \tag{28}$$

$$H_+\psi = E_+\psi, H_-\psi = E_-\psi \tag{29}$$

$$[x, p_-] = [x, -p_+] = -[x, p_+] = -i\hbar \tag{30}$$

$$[x_i, p_{+j}] = +i\hbar\delta_{ij} \tag{31}$$

$$[x_i, p_{-j}] = -i\hbar\delta_{ij} \tag{32}$$

Hamiltonian H_- of minus mass (in harmonic oscillation)

$$H_- = -\frac{1}{2}m\dot{x}^2 - \frac{1}{2}mw^2x^2 \tag{33}$$

$$= -(\frac{P_+^2}{2m} + \frac{1}{2}mw^2x^2) \tag{34}$$

$$= -\hbar w(\frac{mwx^2}{2\hbar} + \frac{P_+^2}{2m\hbar w}) \tag{35}$$

$$= -\hbar w(\sqrt{\frac{mw}{2\hbar}}x + i\frac{P_+}{\sqrt{2m\hbar w}})(\sqrt{\frac{mw}{2\hbar}}x - i\frac{P_+}{\sqrt{2m\hbar w}}) \tag{36}$$

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

$$a = \sqrt{\frac{mw}{2\hbar}}x + i\frac{P_+}{\sqrt{2m\hbar w}} \tag{37}$$

$$a\dagger = \sqrt{\frac{mw}{2\hbar}}x - i\frac{P_+}{\sqrt{2m\hbar w}} \tag{38}$$

N($a\dagger a$) is

$$N = a\dagger a = \frac{mw}{2\hbar}(x^2 + \frac{P_+^2}{m^2w^2} + \frac{i}{mw}[x, P_+]) \tag{39}$$

$$= \frac{1}{\hbar}[\frac{mwx^2}{2} + \frac{P_+^2}{2mw}] - \frac{1}{2} \tag{40}$$

$$= \frac{1}{\hbar}[-\frac{H_-}{w}] - \frac{1}{2} \tag{41}$$

$$H_- = -\hbar w(N + \frac{1}{2}) \tag{42}$$

Eigen value of number operator N

$$N|n\rangle = n|n\rangle \tag{43}$$

$$H_-|n\rangle = -hw(N + \frac{1}{2})|n\rangle \tag{44}$$

$$= -\hbar w(n + \frac{1}{2})|n\rangle \tag{45}$$

$$= E_n^- |n\rangle \tag{46}$$

Therefore,

$$E_n^- = -\hbar w(n + \frac{1}{2})(n = 0, 1, 2, 3, \cdots\cdots) \tag{47}$$

Ground state of minus mass is n=0 state. Eigen value is $E_0^- = -\frac{1}{2}\hbar w$, first-excite state $E_1^- = -\frac{3}{2}\hbar w$

III. Hypothesis of dark matter and dark energy with minus mass

1. Hypothesis of dark matter and dark energy with minus mass

If negative energy and positive energy were born together at the moment of Big Bang, then negative energy would create minus mass, and positive energy could exist in universe as the state of positive energy like plus mass and radiant energy. Minus mass was disappeared near massive plus mass structure(such as planet, star, etc.) after meeting plus mass because of Newton dynamic motion of minus mass and plus mass, but minus mass which was born at the beginning of universe still exists out of galaxy, and this minus mass is the origin of dark energy, which accelerates plus mass in the direction of cosmic expansion and dark matter, which collects galaxy in Galaxy cluster, or stars in each galaxy

1)At the beginning of universe, assume that the pair of positive energy and negative energy was pair production and pair annihilation repeatedly when cosmic energy is 0. $E_T = (+E_+) + (-E_-) = 0$

2)From among $(+E_+)$ and $(-E_-)$, the pair of energy is exists which was not disappeared

3)$E_+ = m_+c^2 + hv$(energy state) Some of them created matter and antimatter matter which had mass, but because of the asymmetry between matter and antimatter matter, they were disappeared each other, then created radiant energy, and some matters survives.

4)But, in case of negative energy, it cannot create particles that have internal structure, because of essential characteristics of minus mass, so it just creates minus mass $E_- = m_-c^2$ only.

5)Therefore, most of negative energy is converted to m_-c^2 which is a type of mass as the temperature falls down at the beginning of universe, whereas positive energy is converted to m_+c^2 and positive energy state(radiant energy), so the velocity that it is converted to mass is relatively slow. According to this, the density of minus mass is considerably greater than that of plus mass at the beginning of universe.

6)At this time, total of potential energy has minus value(described in V-2)

7)As the universe is cooled down, positive energy creates plus mass and stars more and more, thus matter state increases more than energy state.

8)Starting 7 billion years ago, the number of plus mass reached to fixed rate in proportion to minus mass, and from this moment, total potential energy of universe had plus value, thus it entered in the period of accelerating expansion.(described in V-2)

If minus mass and plus mass were born together at the beginning of universe, plus mass has attractive effect each other as seen in Chapter 2, so it forms star and galaxy structure now, and minus mass has repulsive effect each other, so it cannot form any structure, and may spread out uniformly in the whole area of universe as minus mass at the point that it was born.

Owing to the effect of minus mass and plus mass, minus mass was disappeared near massive plus mass structure(such as planet, permanent star, etc.) after meeting plus mass, but minus mass which was born at the beginning of universe can still exist at the vacuum state out of general galaxy as much as the number of plus mass. This minus mass generates the effect of centripetal force which binding plus mass in galaxy or galaxy cluster.

2.Description of the effect of centripetal force and dark matter with minus mass

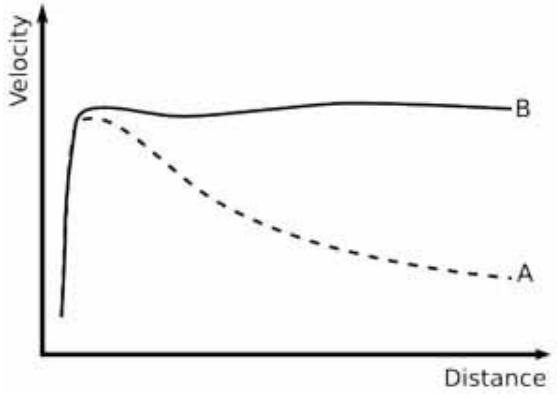

Figure 6: Revolution velocity of galaxy. The revolution velocity through the total quantity of matter that can be observed is A, while the actual observed value is B.

$$V(r)^2 = GM(r)/r \tag{48}$$

$$M(r) = M(r)_{visible} + M(r)_{dark} \tag{49}$$

Currently, from the calculation of total amount of visible matters during general observation of galaxy, it must show the form of Graph A that indicates the revolution velocity of star is decreased as it approaches to exterior of galaxy, but from the value according to actual observation, it shows revolution velocity is almost uniform at

both points whether it is close or far away from center of galaxy as shown in Graph B, and if stars keep currently observed velocity, stars go out without being held in gravity, so generally scientific circles insist that invisible matter that currently holds stars, namely positive dark matter that plays a role of centripetal force should exist there. [3]

For this phenomenon, this paper tries to explain that minus mass can create invisible gravity effect, and extra dark matter effect in galaxy.

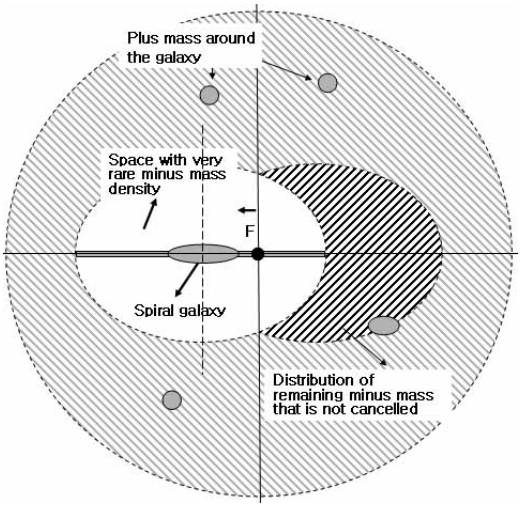

Figure 7: Minus mass effect on arms of galaxy. The actual observed spiral galaxy is on the left. Since repulsive effects occur between minus masses in Newtons dynamics, minus masses will be distributed all over space because it cannot form large mass structures like stars. Minus mass within the galaxy is cancelled out by attraction from large plus mass during the galaxy formation process. Furthermore, the space, other that the galaxy, will maintain the distribution state of minus mass.

When minus mass is distributed uniformly in Fig.7, if we examine the area of galaxy diameter working the gravity on the basis of mass m for the analysis, there is no minus mass in the space of spiral space on the left, so minus mass can exist as much as the size of black and white on the right. Minus mass on the right works the force on plus mass m on the origin to the left(plus mass moves after receiving the force that becomes farther from minus mass), and this direction will be in keeping with the central direction of gravity of real galaxy.

Therefore, finally minus mass which remains on the right works the gravity effect on mass m as much as the same sized plus mass exists on the left.

According to this, plus mass m on the arm of galaxy has received additional centripetal force by minus mass greater than visible plus mass(galaxy mass), so it must have higher velocity V as shown in observation to stay in relevant orbit. Details are explained in [V. Method to prove the existence of minus mass.]

If we explain the same figure in the different way, if minus mass and plus mass of same size exist together in the area of galaxy on the left that there is no minus mass(white area), two mass are completely offset, so that area is just same as empty space. Now minus mass is distributed uniformly in the whole area around mass m located on the origin, so the gravity worked on plus mass m by minus mass is offset each other. Whereas, plus mass which is not offset remains in white area on the left, uniformly distributed plus mass worked additional attraction, namely centripetal force on mass m on the origin.

Accordingly, mass m on the arm of galaxy receives centripetal force by real galaxy, and centripetal force by the distribution of minus mass out of galaxy(the same effect as plus mass is distributed in galaxy).

Dark matter, which is required to explain greater velocity of galaxy as compared with the gravity of galaxy cluster, and greater star's velocity in each galaxy, can be described not only with plus mass.

3. Description of repulsion effect of cosmic expansion and dark energy with minus mass

Minus mass can work additional centripetal force on stars in galaxy as described previously, and also minus mass can provide repulsion which is the origin of cosmic expansion from Newton dynamics.

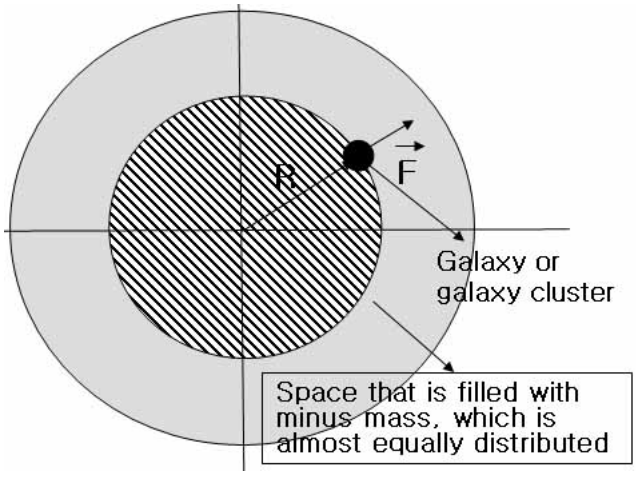

Figure 8: Expansion of the universe by minus mass distribution. The force, which is applied to the galaxy and galaxy cluster and located within radius R from the center of a 3-dimensional space, when assuming equal distribution of minus mass from repulsive effects between minus masses across space is valid.

As considered the problem of the gravity at the point placed on arbitrary radius R of spherical object like the

earth that mass is uniformly distributed [4], the gravity by mass distribution out of radius R is offset each other, and there is only the gravity effect by mass within radius R. If minus mass was born at the beginning of universe together with plus mass, it should be uniformly distributed in universe by repulsion between minus mass. Of course, there can be difference in minus mass density owing to the local distribution of massive plus mass.

For the gravity effect that almost uniformly distributed minus mass has on plus mass(galaxy or galaxy cluster) located in radius R from the center of universe(3-dimensional center), minus mass within radius R only has the gravity effect on plus mass located within radius R, and at this time, plus mass is accelerated in the direction of begin far away from minus mass.

The direction that plus mass becomes farther from minus mass is in keeping with the direction of cosmic expansion, and also minus mass continuously works the force, so finally plus mass is gradually accelerated(expansion velocity becomes faster). As examined in Chapter II, in the description of the force of plus mass and minus mass, the force is repulsion(the direction of +R), and integrated potential energy is plus value. Therefore, the assumption of the existence of minus mass can suggest the explanation of repulsive effect required for cosmic expansion, and the accompanying positive dark energy.

4. The difference in mass when creating the pair of minus mass and plus mass

If plus mass and minus mass simultaneously repeat pair creation and pair annihilation microscopically at the vacuum state which satisfies energy conservation and momentum conservation, to materialize energy and momentum conservation, the size of two mass can be different when creating a pair of plus mass and minus mass because of the existence of potential energy, momentum conservation, etc.

If there is difference between $(-m_-c^2) and (+M_+c^2)$ owing to momentum conservation and energy conservation at the state of repeating creation and annihilation of $-m_-$ and $+M_+$ in a vacuum in an instant(energy conservation can be broken for very short time because of uncertainty principle, so it can be created by such an energy as well), two mass are pair-created. If two mass are pair-annihilated, energy conservation is materialized on the whole, but the gravity by (-m) and (+M) can work on other objects in our universe for very short time before pair annihilation after pair creation

This study calculated dynamically the difference between two mass in accordance with energy and momentum conservation below, if minus mass and plus mass are pair-created in a vacuum.

If we consider the existence of difference in mass when pair creation Minus mass and plus mass that energy conservation is materialized when pair creation and pair annihilation from $E_T = T + U + m_0c^2$

$$E_T = \frac{-m_-c^2}{\sqrt{1-(\frac{v}{c})^2}} + \frac{M_+c^2}{\sqrt{1-(\frac{V}{c})^2}} + \frac{(-GM_+(-m_-))}{r} \quad (50)$$

$$E_T = \frac{-m_-c^2}{\sqrt{1-(\frac{v}{c})^2}} + \frac{M_+c^2}{\sqrt{1-(\frac{V}{c})^2}} + \frac{GM_+m_-}{r} = 0 \quad (51)$$

$$P_T = \frac{-m_-v}{\sqrt{1-(\frac{v}{c})^2}} + \frac{+M_+V}{\sqrt{1-(\frac{V}{c})^2}} = 0 \quad (52)$$

(initial energy 0, initial momentum 0, $M_+ > 0, m_- > 0$,)

In equation (52),

$$\sqrt{1-(\frac{v}{c})^2} = a \quad (53)$$

$$\sqrt{1-(\frac{V}{c})^2} = b \quad (54)$$

are define, equation (52) is

$$\frac{m_-v}{a} = \frac{M_+V}{b} \quad (55)$$

$$m_- = M_+(\frac{a}{b})(\frac{V}{v}) \quad (56)$$

If equation (51) is substituted for equation (53), (54)

$$\frac{GM_+m_-}{r} = \frac{m_-c^2}{a} - \frac{M_+c^2}{b} \quad (57)$$

substituion equation (56) in equation (57)

$$\frac{GM_+}{r} \times M_+(\frac{a}{b})(\frac{V}{v}) = \frac{c^2}{a} \times M_+(\frac{a}{b})(\frac{V}{v}) - \frac{M_+c^2}{b} \quad (58)$$

$$\frac{GM_+}{r} \times (\frac{a}{b})(\frac{V}{v}) = (\frac{c^2}{b})(\frac{V}{v}) - \frac{c^2}{b} \quad (59)$$

Both term $(\frac{b}{a})(\frac{v}{V})$ multiply,

$$\frac{GM_+}{r} = \frac{c^2}{a}(1-\frac{v}{V}) \quad (60)$$

In equation (60), the left term is bigger than 0, thus the right term must be bigger than 0, accordingly,

$$V > v \quad (61)$$

If equation (61) is substituted for equation (56),

$$(\frac{V}{v}) = \frac{m_-b}{M_+a} > 1 \quad (62)$$

$$\frac{m_-}{M_+} > \frac{a}{b} = \frac{\sqrt{c^2-v^2}}{\sqrt{c^2-V^2}} \quad (63)$$

Considering $V > v$, which is the result from equation (61), in equation (63), numerator is bigger than denominator,

$$m_- > M_+ \tag{64}$$

so we can get the result. equation (64) shows that, if minus mass and plus mass are pair-created, there is the difference between minus mass and plus mass when initial energy and momentum are 0 in the system that energy conservation and momentum conservation are materialized.

This difference in mass when minus mass and plus mass pair creation presents that, if minus mass and plus mass were born together at the beginning of universe, minus mass which is not offset from among them can exist in universe now, and also minus mass which is bigger than plus mass can exist. Accordingly, if minus mass is dark matter, it provides the description that total amount of dark matter is bigger than that of matter.

The existence of minus mass provides quantitative description of the existence of dark matter and dark energy, it can make it possible that energy value which is the origin of initial state of universe can be 0, and this has a very important meaning.

5.The universe expands even if the size of minus mass is the same as that of plus mass

In previous particle physics, according to the case of the birth of antimatter, when pair-creating particles symmetrical to certain particle, their physical quantities are the same each other, according to the situation that has opposite specific value, when pair-creating minus mass and plus mass, the size of absolute value of minus mass is the same as that of plus mass, and minus mass and plus mass of same number were born, and this study tries to consider the cosmic expansion when the distance between them is similar.

1)Potential energy when there is one pair of minus mass and plus mass U

$$U_1 = -\frac{G(m_+)(-m_-)}{r} = +\frac{G(m_+)(m_-)}{r} = \frac{Gm_+^2}{r} \tag{65}$$

(if,$m_+ = m_-$)

2)Potential energy when there is two pair of minus mass and plus mass U

$$U = \sum_{i=1}^{6} U_i = \sum U_+ + \sum U_- \tag{66}$$

$$U = \sum U_+ + \sum U_- = (U_1 + U_2 + U_3 + U_4) + (U_5 + U_6) \tag{67}$$

$$= 4\frac{Gm_+m_-}{r} - (\frac{Gm_+m_+}{\sqrt{2}r} + \frac{Gm_-m_-}{\sqrt{2}r}) \tag{68}$$

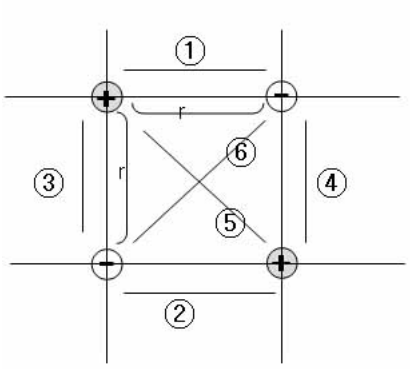

Figure 9: Arranges 1 when 2 pairs of minus and plus masses exist

$$= 4\frac{Gm_+^2}{r} + 2(-\frac{Gm_+^2}{\sqrt{2}r}) \tag{69}$$

$$= (4 - \sqrt{2})(\frac{Gm_+^2}{r}) \tag{70}$$

($m_+ = m_-$)

Potential energy has plus value, so there is repulsion, and the universe expands. We can know that the universe expands at the state that the size of minus mass is the same as that of plus mass, and the number was identically born

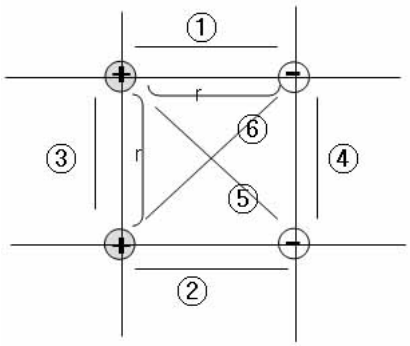

Figure 10: Arranges 2 when 2 pairs of minus and plus masses exist

$$U = \sum_{i=1}^{6} U_i = \sum U_+ + \sum U_- \tag{71}$$

$$U = \sum U_+ + \sum U_- = (U_1 + U_2 + U_5 + U_6) + (U_3 + U_4) \tag{72}$$

$$= 2(\frac{Gm_+m_-}{r} + \frac{Gm_+m_-}{\sqrt{2}r}) - (\frac{Gm_+m_+}{r} + \frac{Gm_-m_-}{r}) \tag{73}$$

$$= 2(\frac{Gm_+^2}{\sqrt{2}r}) \tag{74}$$

$$= \sqrt{2}(\frac{Gm_+^2}{r}) \quad (75)$$

(if, $m_+ = m_-$)

Potential energy has plus value, so there is repulsion, and the universe expands.

We can see that potential energy keeps plus value at the state that the size of minus mass is the same as that of plus mass, and the number was identically born, although there is difference in the value of potential energy according to the distribution of each mass. Therefore, potential energy is plus, thus the force is plus, and the universe expands.

3)Potential energy when there are generally n pairs of minus mass and plus mass:

$$U_n = \sum_{i=1}^{n^2} U_{+i} + \sum_{j=1}^{n(n-1)} U_{-j} \quad (76)$$

(U_+:plus potential energy, U_-:minus potential energy)

If n pairs of minus mass and plus mass are created, generally the number of term of plus potential energy is n^2, the number of term of minus potential energy is n(n-1), so the number of term of plus potential energy is greater than that of term of minus potential energy by n. Accordingly, even if the absolute value of minus mass is the same as that of plus mass at the beginning of universe, the universe has the value of plus potential energy, and expands.

6. The effect of gravitational lensing

Generally, it is possible to examine the existence of dark matter with the existence of additional mass with the effect of gravitational lensing. If minus mass is dark matter, so if we try to examine the effect of gravitational lensing, previously the gravity between plus mass is attraction, so it has the shape of convex lens to collect within the form, whereas the force between minus mass and plus mass is repulsion, so a set of massive minus mass can make the effect that distorts observation target in the form of concave lens.

If existing measuring instrument recognizes the effect of gravitational lens with distorted aspect of galaxy or galaxy cluster, the effect of concave gravitational lensing owing to the existence of minus mass also plays a role of distorting galaxy or galaxy cluster, so it can be the basis of invisible dark matter. Additionally, in the distribution of dark matter suggested with previously measured effect of gravitational lens, dark matter may be created purely by plus mass, but also it can be created by the distribution of dark matter by minus mass.

But in the hypothesis of dark matter with minus mass in this study, minus mass is distributed out of galaxy, not within galaxy. Therefore, the effect of concave gravitational lensing by minus mass out of galaxy will be presented to an observer on the earth in the same form as the effect of convex gravitational lensing which galaxy works.

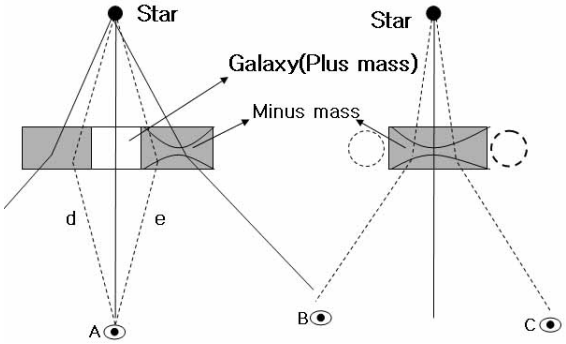

Figure 11: Concave Gravitational lensing effect. The left side is the Gravitational lensing effect that occurs when the galaxy is surrounded by minus mass and the right side is Gravitational lensing effect that occurs when plus mass exists alone

No the effect of concave gravitational lensing by minus mass has been observed. However, we have never thought about minus mass itself, so we might not have thought about the concave gravitational lensing as well, and it might be difficult to classify the effect of concave gravitational lensing and the effect of convex gravitational lensing.

For the situation presented on the left when observing the light on the earth which passed through galaxy surrounded with minus mass, this study suggested that there is invisible dark matter in galaxy, and owing to this gravity it can be happened owing to the effect of convex lens, it means, if there is any matter on the left and right side of galaxy that plays a role of concave lens, it is difficult to classify convex lens and its form.

According to the explanation of the effect of concave gravitational lensing from the viewpoint of gravity, not geometrical optics, there is the effect of centripetal force by the distribution of minus mass out of galaxy with the effect of centripetal force in galaxy as described previously, so there is real mass of galaxy + the gravity when filling the whole galaxy with plus mass that has the same density as that of minus mass in galaxy. Therefore, if the light from the exterior passes inside of galaxy or near galaxy, real gravity of galaxy + gravity of dark matter(by minus mass) is added, and finally it will present much greater effect of gravitational lensing.

If we consider the situation that we can observe purely the effect of concave gravitational lensing, that situation is just the same as the situation when there is single concave lens on the right in Figure above. First, an observer on the earth must observe it on Position B and C after moving by considerably great distance as compared with

the size of galaxy, but the earth has never changed the position of observation from the target for distant observation. second, real observation on the earth is the single B or C situation in Figure on the right, and if an observer on the earth performed observation previously on C, generally an observer of C would describe the effect of gravitational lensing is generated because there is invisible dark matter on the right of black and white area(circle drawn with dotted line on the right).

7. Description of interaction between dark matters when colliding with galaxy clusters

As shown in the recent observation of dark matter, dark matter seems not to interact with each other when colliding with galaxy clusters [5], and it can be predicted with essential characteristics of minus mass.

Uniformly distributed minus mass receives attractive effect from massive plus mass, so dark matter which has minus mass is clustered around galaxy because of attraction of galaxy. If the type of force worked between minus mass when colliding with galaxy clusters is repulsive, and minus mass is distributed almost uniformly without forming massive mass structure, the shape of dark matter is not distorted or transformed even if dark matter(minus mass) and dark matter(minus mass) pass through similar area, that is, they will seem not to interact each other. Also there is repulsive effect between dark matters that are made up with minus mass, thus there will be almost no direct collision as well.

Repulsive effect that is the nature between minus mass as described above provides the proper description that existing dark matters do not interact each other, although they interact gravitationally with plus mass.

As the factor that breaks the uniform distribution of minus mass, first, minus mass receives the attractive effect from massive plus mass, thus for the distribution of minus mass near massive plus mass such as galaxy or galaxy cluster, the density of minus mass is higher as it is closer to galaxy or galaxy cluster, and is lower as it is farther. Second, If plus mass(like galaxy) that has strong gravity or interstellar cloud that has plus mass pass through existing area that minus mass is distributed, minus mass can be disappeared when meeting plus mass or it can be drawn owing to attractive effect of massive plus mass at this moment, so there can be the area that minus mass, namely, dark matter is not uniformly distributed

8. Solution for the difficulty in description with cosmological constant and vacuum energy

From the observation of universe, now we know that the universe expands, and to explain this expansion, we try to explain cosmic expansion with the thought of cosmological constant and vacuum energy, etc., but cosmological constant and vacuum energy [3] threats the causationism that is the basis of science, and the energy conservation that is fundamental characteristic of our universe. At least, minus mass observes energy conservation and momentum conservation. This means minus mass is not serious target more than cosmological constant or vacuum energy in physics, although it is more difficult to imagine the existence of minus mass more than cosmological constant or vacuum energy.

IV. Explain for the problem of non-observation with the characteristics of minus mass

As examined with Newton dynamics of minus mass, attraction works between plus mass, and they have attractive effect, so they gradually clusters each other, and then make massive mass like planet or star. On the other hand, attraction works between minus mass, but they have repulsive effect, and nuclear force cannot form nucleons by binding minus mass, so they cannot make massive mass structure like planet or star. This explains that existing dark matter is not an interruption in forming galaxy while the universe is growing.

When matter and antimatter are pair creation and pair annihilation, antimatter also had basically plus mass, so gamma rays were emitted when pair annihilation, and with this phenomenon, the existence of antimatter was proved, but pair annihilation of minus mass and plus mass is in the form of (E) + (+E) = 0, thus generally gamma rays are not emitted after pair annihilation. So it seems to be more difficult to detect.

Bubble box that detects a charged particle used in accelerator also is useless when minus mass is not charged, it cannot be valid means because minus mass cannot draw the trace itself with pair annihilation, and Thought wall of minus mass was too big. However, the essential reason is that energy value which can pair creation create minus mass and plus mass might be limited at the beginning of universe.

The reason why we have not found minus mass on the earth until now is that minus mass exists as the state of mass when it was born without forming massive mass structure which can be easily measured owing to basic characteristics of minus mass(repulsive effect) as described above, and that minus mass is not observed because minus mass which exists around massive plus mass such as earth or the solar system receives attractive effect from massive plus mass, and it was disappeared long time ago when forming galaxy, even if it existed at the beginning of universe.

There is no observation of minus mass until now, but basic characteristics of minus mass and aspect of dynamic

motion with plus mass strangely provide the proper description of dark matter and dark energy in our universe.

The characteristics of minus mass uniformly satisfy the effect of centripetal force which existing dark matter in galaxy or galaxy cluster, the fact that it does not interrupt to form galaxy even though it has gravitational interaction, difficult element for the observation, very low interaction between dark matters when colliding with galaxy or galaxy clusters, repulsion energy required for cosmic expansion, repulsive effect on plus mass, etc.

On the other hand, minus mass also has the wall of thought that generally it is difficult to accept. However, we can say about the wall of thought, minus mass just collides with our a fixed idea, and it does not collide with energy conservation or momentum conservation.

Some people deny minus mass because it cannot be accepted in the abstract, but it is necessary to refer to the fact that the quantum theory or the theory of relativity in 20th century is contradicted with existing fixed idea, provide quantitative explanation of dark matter and dark energy, and then to perform an experiment targeting on the observation of minus mass.

V. Method to prove the existence of minus mass

1. Calculating centripetal force in galaxy from minus mass distributed out of galaxy

This study mentioned the effect of centripetal force described previously, and the effect of centripetal force of minus mass with the description of dark matter(Fig.7). The researcher suggests that it is possible to prove the existence of minus mass with the comparison between observed value and revolution velocity of star according to the distance in galaxy which is calculated from minus mass distributed out of galaxy.

$$V(r)^2 = GM(r)/r \tag{77}$$

$$M(r) = M(r)_{visible} + M(r)_{dark} \tag{78}$$

From the calculation of centripetal force in Newton dynamics(refer to Fig.7), the important matters to calculate gravity effect of minus mass are the size and model of empty space of minus mass by real galaxy on the left, in case of spiral galaxy or oval galaxy, it may be close to oval if we consider the fact that most of mass is placed on galaxy core, the rotation of galaxy, and the gravitational radius of galaxy core, thus we regard empty space of minus mass as spherical or oval, and perform calculation to compare with observed value.

$$\frac{mv^2}{r_+} = \frac{GM_+(r_+)m}{r_+^2} + \frac{GM_-(r_-)m}{r_-^2} \tag{79}$$

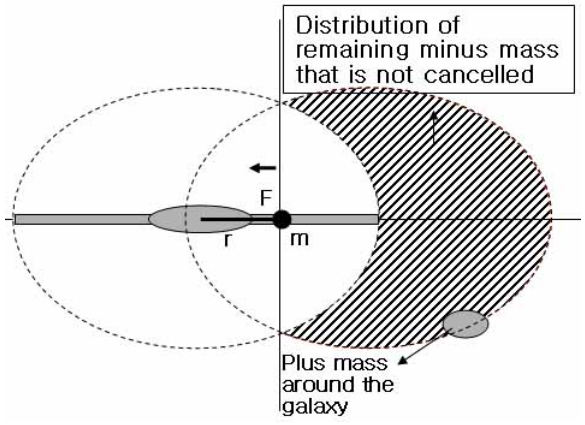

Figure 12: Effective minus mass. The minus mass distribution, where gravity is applied without cancellation of the oblique field located on the right side.

$(M_+(r_+) > 0, M_-(r_-) > 0)$

Adding the term of centripetal force by minus mass to the term of centripetal force by plus mass as described above, we compare revolution velocity of star and the density of minus mass, then expand this to apply to other galaxies, and we can inspect if the interpretation of dark matter distributed out of galaxy is proper or not.

The distribution of minus mass that remains without being offset in Fig. 12 is crescent-shaped, so it seems to be difficult to calculate, but if we assume that the white empty space on the left is full with minus mass and plus mass at the same density, here minus mass is uniformly distributed over the whole area, so the effect of minus mass on mass m is 0. Remaining plus mass is distributed over the white area on the left at the density of minus mass, and the gravity that uniformly distributed plus mass works on plus mass m place on radius r is worked only by the distribution of mass within radius r.

Therefore, the effect of minus mass that remains out of galaxy without being offset can make it approximate to the gravity generated by the distribution of plus mass within the radius R in galaxy

$$M_- = \rho_-(r)V = \rho_-(r)(\frac{4\pi r^3}{3}) \tag{80}$$

In equation(79)

$$\frac{mv^2}{r_+} = \frac{GM_+(r_+)m}{r_+^2} + \frac{GM_-(r_+)m}{r_+^2} \tag{81}$$

$$v = \sqrt{\frac{G(M_+ + M_-)}{r_+}} = \sqrt{\frac{G(M_+ + \rho_-(r_+)V)}{r_+}} \tag{82}$$

$$v = \sqrt{\frac{GM_+}{r_+} + \rho_-(r_+)(\frac{4\pi r_+^2}{3})} \tag{83}$$

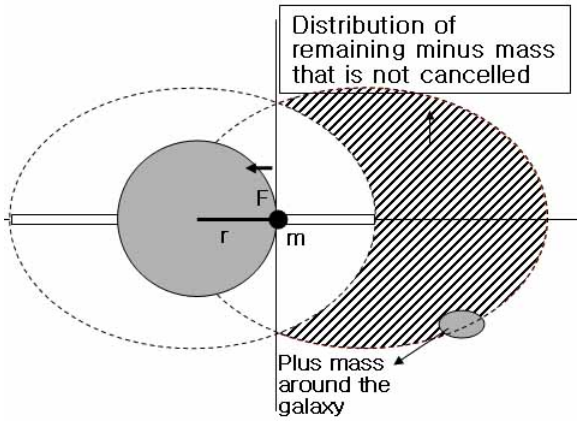

Figure 13: Equal to the degree of gravity that is applied on the equally distributed plus mass within the radius r of the left side. The gravitational effect from minus mass, which functions at mass m is equal to the gravitational effect from plus mass within radius r.

The mass density of collisionless isothermal sphere is given as $\rho(r) = \frac{\sigma^2}{2\pi G r^2}$ [7] in galaxy dynamics. σ^2 is velocity dispersion.

$$M_{dark} = M_{minus} = \frac{2\sigma^2}{3G} r \tag{84}$$

equation (83) is applied to arbitrary spherical or oval galaxy, and in case of normal shaped spiral galaxy, the distance which spherical approximation can be applied from the center of galaxy will be effective.

So if we consider that the distribution of minus mass out of galaxy comes under isothermal, the effect of mass in galaxy by the distribution of minus mass out of galaxy is proportional to r as shown in equation (84), and this is in keeping with observed dark matter.

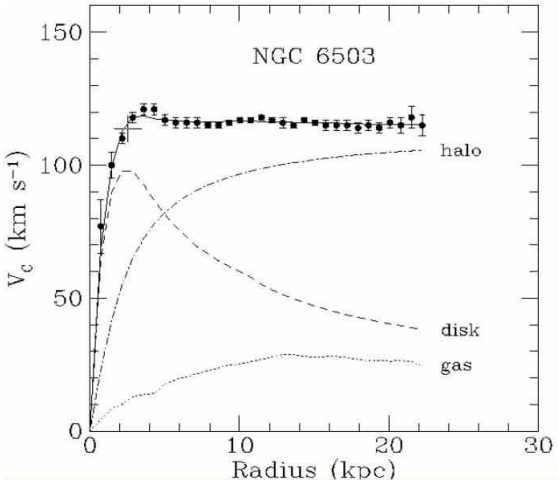

Figure 14: Revolution velocity of NGC 6503

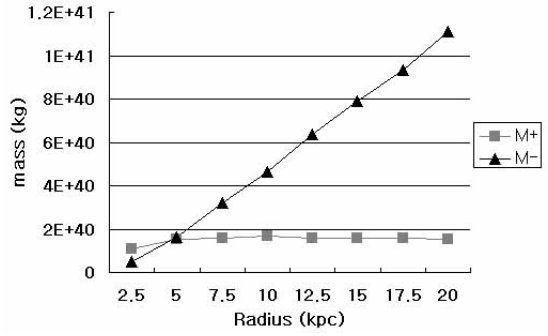

Figure 15: Distribution of plus mass and minus mass on NGC6503. The distribution of the galaxy mass, which is can be observed, is mostly in the galaxy nuclei, while the effects of minus mass, which is distributed over the outside of the galaxy, increases with the ratio of distance r.

NGC 6503 in Fig.14 is oval galaxy, and the graph shows the total amount of dark matter with the distribution of minus mass that remains without being offset from minus mass out of galaxy.

Plus dark matter distributed in galaxy does not form the spherical distribution, and it is broken owing to the gravity of galaxy core, gravitational action with stars, and rotation of galaxy, if its shape is not very intentionally assumed. Furthermore, there are various heat sources in galaxy according to position, so it cannot be regarded as collisionless Isothermal. However, the effect of centripetal force that minus mass works from the exterior of galaxy can keep the spherical distribution of mass, and make the mass effect that increases linearly in accordance with distance r as seen above because it receives less influence from elements such as the gravity of galaxy core, or rotation of galaxy.

2. Description of cosmic decelerating expansion and accelerating expansion

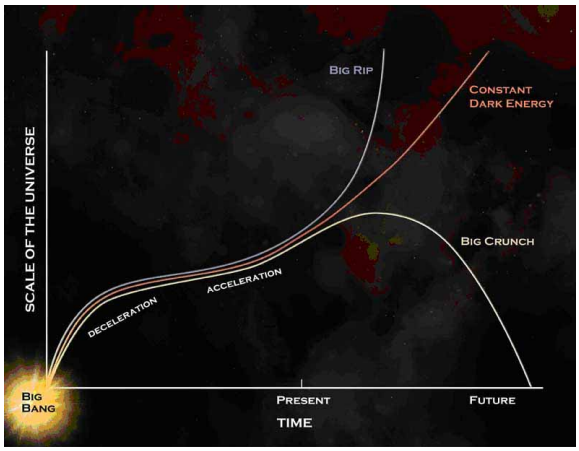

Figure 16: Deceleration and acceleration of the universe

Fig.16 shows current cosmic expansion. Currently expansion velocity of our universe was reduced owing to attraction of matter, and it has increased again for last 7 billion years.

Minus mass worked repulsion on plus mass give an effect of centripetal force to plus mass in galaxy, and it plays a role of dark energy that expands plus mass on the whole of universe. Now this study tries to describe cosmic decelerating and accelerating with minus mass that expands the universe.

From [III-5. cosmic expands even if the size of minus mass is the same as that of plus mass] described previously, the fact that potential energy between two is not 0, even if the size of minus mass is the same as that of plus mass, and it suggests something to pay attention in treating minus mass.

In [III-1] above, the number of minus mass was greater than that of plus mass at the beginning of universe, so if we induce how many terms of potential energy survive when the number of minus mass is greater than that of plus mass,

U_+:Plus potential $(+\frac{GMm}{r})$,

U_-:Minus potential $(-\frac{GMm}{r})$, U_T:Total potential

Focus on the number of terms of remaining potential energy rather than the concrete value of potential energy,

*Potential energy between plus mass and plus mass has value:$U = (\frac{-Gm_+m_+}{r}) = 1U_-$

*Potential energy between minus mass and plus mass has + value:$U = (\frac{-G(-m_-)m_+}{r}) = 1U_+$

*Potential energy between minus mass and minus mass has value:$U = (\frac{-G(-m_-)(-m_-)}{r}) = 1U_-$

(if, $U_+ = -U_-$)

1)When the number of minus mass is 2, and the number of plus mass is 1

$$U_T = 2(\frac{-G(-m_-)m_+}{r}) + (-\frac{G(-m_-)(-m_-)}{r}) = 2U_+ + 1U_- = 1U_+ \quad (85)$$

2)When the number of minus mass is 3, and the number of plus mass is 1

$$U_T = 3U_+ + 3U_- = 0 \quad (86)$$

3)When the number of minus mass is 4, and the number of plus mass is 1

$$U_T = 4U_+ + 6U_- = -2U_+ \quad (87)$$

4)When the number of minus mass is 4, and the number of plus mass is 2

$$U_T = 8U_+ + 7U_- = 1U_+ \quad (88)$$

5)When the number of minus mass is n_-, and the number of plus mass is n_+, total potential energy is given as follows.

$$U_T = (n_- \times n_+)U_+ + (\frac{n_-(n_- - 1)}{2}U_- + \frac{n_+(n_+ - 1)}{2}U_-) \quad (89)$$

equation (89) is expressed as follows more strictly

$$U_T = \sum_{i,j}^{i=n_-,j=n_+} (\frac{Gm_{-i}m_{+j}}{r_{+-ij}}) + \sum_{i,j,i\neq j}^{i,j=n_-} (\frac{-Gm_{-i}m_{-j}}{r_{--ij}}) + \sum_{i,j,i\neq j}^{i,j=n_+} (\frac{-Gm_{+i}m_{+j}}{r_{++ij}}) \quad (90)$$

$$U_T = (n_- \times n_+)(\frac{Gm_-m_+}{\bar{r}_{+-}}) + (\frac{n_-(n_- -1)}{2}(\frac{-Gm_-m_-}{\bar{r}_{--}}) + \frac{n_+(n_+ - 1)}{2}(\frac{-Gm_+m_+}{\bar{r}_{++}})) \quad (91)$$

$(U_+ = (\frac{Gm_-m_+}{\bar{r}_{+-}}), U_- = (\frac{-Gm_-m_-}{\bar{r}_{--}}), U_- = (\frac{-Gm_+m_+}{\bar{r}_{++}})$

$\bar{r}_{+-}$:The mean distance between plus mass and minus mass,

$\bar{r}_{--}$:The mean distance between minus mass and minus mass,

$\bar{r}_{++}$:The mean distance between plus mass and plus mass)

Calculate the value of $U_- = -U_+$, $n_- = 10, n_+ = 1 - 10$ with equation (89) when there is a difference in the number between minus mass and plus mass to examine changes,

(n_-, n_+)

$(10,1)U_T = 10U_+ + 45U_- = -35U_+$

$(10,2)U_T = 20U_+ + 46U_- = -26U_+$

$(10,3)U_T = 30U_+ + 48U_- = -18U_+$

$(10,4)U_T = 40U_+ + 51U_- = -11U_+$

$(10,5)U_T = 50U_+ + 55U_- = -5U_+$

$(10,6)U_T = 60U_+ + 60U_- = 0$

$(10,7)U_T = 70U_+ + 66U_- = 4U_+$

$(10,8)U_T = 80U_+ + 73U_- = 7U_+$

$(10,9)U_T = 90U_+ + 73U_- = 9U_+$

$(10,10)U_T = 100U_+ + 90U_- = 10U_+$

We can see the change in total potential energy in accordance with the difference in the number of minus mass and plus mass from 10 samples above.

- The tendency of total potential energy in accordance with the number of minus mass and plus mass -

i)In specific ratio of the number of minus mass to the number of plus mass, the total potential energy has 0. When the universe is flat.(ex. $(n_-, n_+) = (10, 6)$) Here, we note that total potential energy does not have 0 when general matter comes under 60% of dark matter. 60% is the proportion by assuming that all terms of potential energy are identical, and prescribing that the number of n_- is 10.

ii)If number of plus mass less than specific number, total potential energy has value. Cosmic decelerating expansion

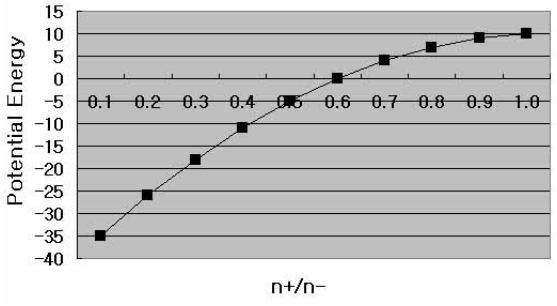

Figure 17: Potential energy from ratio of minus mass and plus mass

iii)If number of plus mass over than specific number, total potential energy has plus value. Cosmic accelerating expansion

iv)The value of total potential energy increases as the number of plus mass approaches to the number of minus mass.

v)If the number of pair of minus mass and plus mass is n, n terms of positive potential remains as shown in equation (76). Final state of universe.

The analysis above can describe that current universe expanded with decelerated speed approximately 7 billion years ago, whereas it expanded with accelerated speed in last 7 billion years [6], and most of negative energy was converted to minus mass owing to the characteristics of negative energy and positive energy pair-created at the beginning of universe, whereas positive energy was born as radiant energy which does not have positive matter and mass, at this time, it expanded with decelerated speed because total potential energy had minus value, then plus matter gradually increased as the universe was cooled down and currently it entered in accelerating expansion which total potential energy of universe has plus value after passing through the point that total potential energy of universe is zero.

6)Calculation of basic arrangement that there are two pairs of minus mass and plus mass

In basic arrangement of Fig.9, calculate total potential energy by setting $m_- = km_+$, ($k \geq 1$:the absolute value of minus mass is greater than that of plus mass) in equation (68),

$$U_T = 4\frac{Gm_+km_+}{r} - (\frac{Gm_+m_+}{\sqrt{2}r} + \frac{Gk^2m_+m_+}{\sqrt{2}r}) \quad (92)$$

$$= [4k - (\frac{1}{\sqrt{2}} + \frac{k^2}{\sqrt{2}})](\frac{Gm_+m_+}{r}) \quad (93)$$

If $U_T \geq 0$,

$$-(k^2 - 4\sqrt{2}k + 1) \geq 0 \quad (94)$$

There are three reasons that total potential energy is greater than 0. First, there are 4 terms of plus potential, and 2 terms of minus potential, second, when k=1, total potential energy is greater than 0 as shown in equation (70), and third, currently the universe has expanded with accelerated speed.

$$(k - 2\sqrt{2})^2 \leq 7 \quad (95)$$

$$-\sqrt{7} + 2\sqrt{2} \leq k \leq +\sqrt{7} + 2\sqrt{2} \quad (96)$$

Consider $k \geq 1$,

$$1 \leq k \leq 5.47417 \quad (97)$$

In $m_- = km_+$, k=5.47417 is the value of that total potential energy U becomes zero. Now according to the result of observing WMAP [8], dark matter has energy as 5.1($\pm$0.4) times as that of general matter, and this is similar to k that is generated when total potential energy of universe U=0. It is difficult to consider that the arrangement(correspondence uniformly distribution) of Fig.9 describes the state of universe exactly, but our universe entered in the period of accelerating expansion 7 billion years, and it is still near critical density, so we can consider total potential energy is close to 0, and suggest something with the fact that k, the proportion of minus mass to plus mass, is similar with the size of mass ratio of dark matter to general matter.

In III-1 above, it described that the quantity of minus mass decided at the beginning of universe can explain the effect of centripetal force in galaxy(V-1), repulsion effect on cosmic expansion(III-3), decelerating expansion at the first half, and accelerating expansion(V-2) of universe at the second half(7 billion years ago) at the same time. Therefore, it is necessary to try to calculate and observe minus mass more strictly, laying aside the abstract aversion of minus mass.

3.Dark matter and dark energy come from one origin

The hypothesis of dark matter and dark energy with minus mass insists that dark matter is not different from dark energy each other, dark matter is the effect of centripetal force by minus mass out of galaxy, and dark energy required to explain cosmic expansion is the repulsion that minus mass works on plus mass on the whole of universe, and the plus potential energy, its integral value.

Accordingly, if we calculate the distribution and mean density of minus mass that describes rotation velocity within galaxy, and explain accelerating expansion of current universe with the size of potential energy that has positive value by this minus mass, we can prove the hypothesis that minus mass is the origin of dark matter and dark energy. It is necessary to consider the meaning of equation (65),(70),(75),(76) in this course.

In 1998 year, observation by HSS(The High-z Supernova Search) team, I have seen a calculation that if the cosmological constant is 0,

$\Omega_M = -0.38(\pm 0.22)$ [9]

Therefore, the quantity of the matter couldn't be negative value, so as far as I know, the value is trashed away.

We have to know that not the formula has disposed the value, but our thought disposed that value

In hypothesis with minus mass,

E_T = plus mass(4.6) + minus mass(x) + 0Λ(72.1)

(minus mass≥plus mass, cosmological constant $\Lambda = 0$)

if minus mass=23.3 % ,

E_T = plus mass(16.5 %) + minus mass(83.5 %)

If cosmological constant Λ=0 and mass density of universe is minus value, to get the age of the universe.

From Friedmann equation,

$$t_0 = \frac{1}{H_0}\int_0^1 \frac{xdx}{\sqrt{\Omega_M x + \Omega_R + \Omega_\Lambda x^4 + \Omega_K x^2}} \tag{98}$$

$\Omega_M = -0.38(\pm 0.22)$,$\Omega_R h^2 \approx 4.16 \times 10^{-5}$,$\Omega_\Lambda = 0$

Use to $\Omega_K = 1 - \Omega_\Lambda - \Omega_M$=1.38 , $H_0 = 100h$ km/s/Mpc, h=0.701

define to $\Omega_K = a, \Omega_M = b, \Omega_R = c$,

$$t_0 = \frac{1}{H_0}\int_0^1 \frac{xdx}{\sqrt{\Omega_K x^2 + \Omega_M x + \Omega_R}} = \frac{1}{H_0}\int_0^1 \frac{xdx}{\sqrt{ax^2+bx+c}} \tag{99}$$

$$t_0 = \frac{1}{H_0}\left[\frac{\sqrt{ax^2+bx+c}}{a} - \frac{b}{2a}\int_0^1 \frac{dx}{\sqrt{ax^2+bx+c}}\right] \tag{100}$$

$$t_0 = \tfrac{1}{H_0}\left[\tfrac{\sqrt{ax^2+bx+c}}{a}\right]_0^1 - \frac{1}{H_0}\left[\frac{b}{2a}\frac{1}{\sqrt{a}}\ln(2\sqrt{a}\sqrt{ax^2+bx+c}+2ax+b)\right]_0^1 \tag{101}$$

$$t_0 = 14.225 Gyr \tag{102}$$

This value is approach to the t=13.73 Gyr calculated in a WMAP. Considering the very large changes(Λ=0 and $\Omega_M = -0.38$), it seems to increase existence probability of minus mass.

Additionally, if $\Omega_M = \Omega_{visible}(4.6) + \Omega_{dark}(-23.3) = -18.7$, we get the t_0=14.927 Gyr

4. Effect of concave gravitational lensing

As observed the effect of concave gravitational lensing mentioned in III-6. Effect of gravitational lensing, this can be the evidence for the existence of minus mass.

5.Description of formation of void and galaxy

If there were plus mass and minus mass at the beginning of universe, and there was minute cave caused by pair annihilation of plus mass and minus mass, it could grow to the present scale through cosmic expansion. It is difficult to explain present large-scale Void only with the uniform distribution of plus mass.

Also, as considered cosmic expansion velocity in the process of forming galaxy, it is difficult to form galaxy structure with uniformly distribute plus mass. On the other hand, from the uniform distribution of minus mass and plus mass, we can explain the formation of galaxy owing to the situation that naturally breaks uniform distribution of matters such as attraction effect between plus mass, repulsion effect between minus mass, attractive effect between massive plus mass and minus mass, and Void caused by pair annihilation.

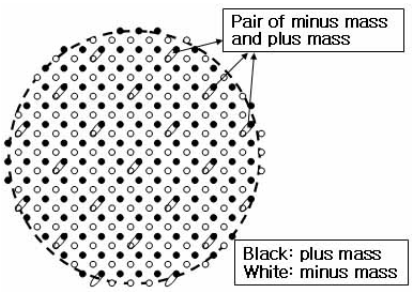

Figure 18: Pair creation

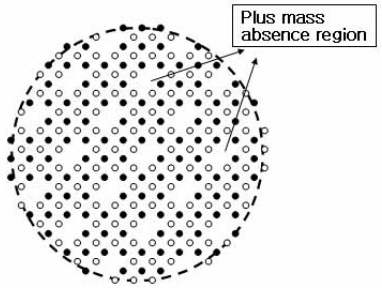

Figure 19: Plus mass absence region by pair annihilation or gravity effect

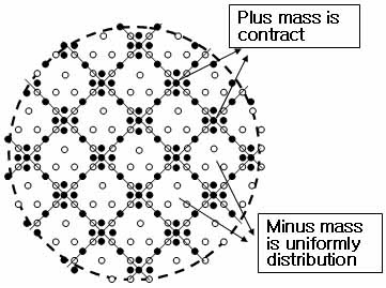

Figure 20: Contraction of plus mass

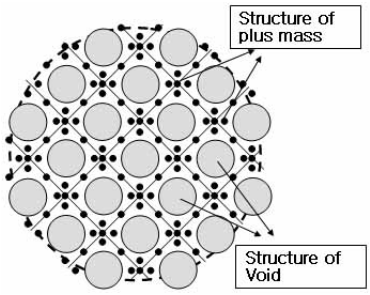

Figure 21: Structure of universe

Making simulation model of the initial state of universe under the assumption of uniform distribution of plus mass and minus mass, we can prove the formation of current Void and galaxy structure and on the basis of this, we can prove the possibility of the existence of minus mass.

6. Possibility to explain mechanism of inflation

Pair creation of minus mass and plus mass seems to provide the proper explanation of homogeneity, local non-homogeneity, and flatness of our universe without separate assumption with basic characteristics of Newton dynamics.

With reference to the flatness of universe, the calculation of cosmic critical density with previous plus mass leads to the problem that present density should be close to critical density, the cosmic density at the beginning should be close to critical density, and initial condition should be set delicately. [3] However, according to the hypothesis of minus mass, potential energy of universe is not single potential when there is only plus mass(potential that has both + and -), and the density of universe close to critical density was from basic mechanism of pair creation, namely 1:1 correspondence of minus mass to plus mass.

If we try to explain the start and natural end of inflation with minus mass for inflation mechanism, and phase transition which the gravity is separated was generated at the beginning of universe when vacuum state was $E_T = (E_-) + (E_+) = 0$, the separation of gravity means the existence of mass, $E_- = m_-c^2$, $E_+ = m_+c^2$ so we can consider that both minus energy and plus energy were converted to mass.

As seen in equation (76) and (V-2.) above, total potential energy has the biggest positive value when the number of plus mass is similar or equal to that of minus mass, if all energy was converted to mass when the gravity was separated, it can explain that there was very big plus potential value at that time, and it can explain the reason of the start of Big Bang and inflation.

If we consider that inflation started at the point of time that there were large-scale pair creations of minus mass and plus mass after Big Bang, not at the point of time that the gravity was separated, the number of plus mass and minus mass might be born together at this time, so here also the term of plus potential energy by equation (76) nU_+(if pair creations are 10^{80}, $U_T = 10^{80}U_0$ survives), and this can provide the start power of inflation.

If plus mass is converted to radiant energy or energy when strong interaction, weak interaction, and electromagnetic force are separated after the start of inflation, the number of plus mass falls down below critical ratio which total potential energy is 0 in (V-2.), so at this time, inflation also is naturally completed.

For fine tuning problem of critical mass density in early universe,

Universe mass density is same critical mass density, that is correspond with total potential energy=0

define, $x = n_-, y = n_+$, if

$$U_{+-} = -U_{--} = -U_{++} = U \tag{103}$$

equation(91) is

$$U_T = \frac{2xy - x^2 + x - y^2 + y}{2}U \tag{104}$$

Consider of uniformly distribution, it is near to stable state when three value of potential energy are almost in same level. So I consider that these three potential can be the same U

If x=y=n,

$$U_{\max} = nU \tag{105}$$

If, $x \to \infty, y \to \infty; n_h(t) = \frac{y}{x} = \frac{n_+}{n_-}$

$$U_T = -\frac{x^2}{2}[\{1 + (\frac{y}{x})^2 - \{\frac{2y}{x} + \frac{1}{x} + \frac{y}{x^2}\}]U \tag{106}$$

$$U_T \simeq -\frac{x^2}{2}[\{1 + (\frac{y}{x})^2 - \{\frac{2y}{x} + 0 + 0\}]U \tag{107}$$

$$U_T = -\frac{x^2}{2}(1 - \frac{y}{x})^2U \tag{108}$$

$$U_T = -\frac{n_-^2}{2}(1 - n_h(t))^2U \tag{109}$$

Total potential energy is propotion square term of minus mass number(similar plus mass number)

divide U_{max} by equation(104),

Ratio of potential size

$$\frac{U_{\max}}{|U_T|} = \frac{n_-}{\frac{n_-^2}{2}(1 - n_h(t))^2} = \frac{2}{n_-(1 - n_h(t))^2} \tag{110}$$

n_- is total number of minus mass. If n_- is 10^{80}, we can know how the present potential values are smaller

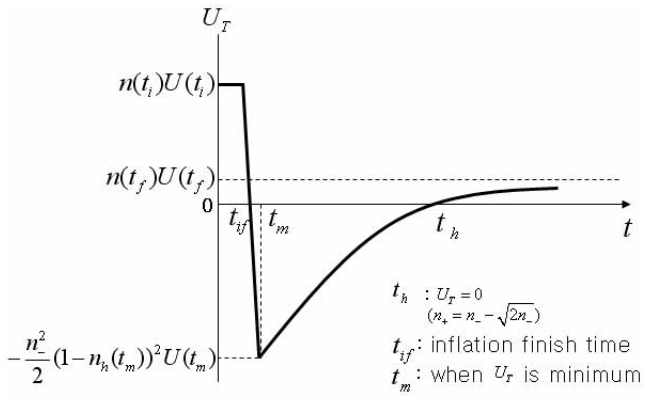

Figure 22: Changes in potential energy over time

than the maximum potential values of universe, how this present potential value is close to zero.

About the fine tuning of critical density in the early universe, even though the density of present universe is equally same with the value of critical density, when minus mass and plus mass coexist, it doesn't mean that the density of early universe must be very close with the value of critical density. And also because minus and plus mass's rate is going close to 1, that present universe is almost at the same with critical density values.

In fig.22, minus and plus mass created n pairs, and in this period that potential energy values in $U_{\max} = nU$. That cause accelerates expansion of universe(inflation).

Strong interaction, weak interaction and electromagnetic force are separate and also antimatter and matter generate pair annihilation in during inflation. So most of plus matter became radiation. Then total potential energy become minus value(result of V-2, fig.17). And we call this time t_{if}(inflation finish time)

As the universe is getting cooler, the radiation is getting lower and that radiation changed the matter with plus mass. And after values of plus mass became the critical ratio of minus mass, that potential energy becomes zero. We call this time by t_h. Plus mass number is

$$n_+ = n_- - \sqrt{2n_-} \tag{111}$$

According to hypothesis with minus mass, The last state of universe is when plus mass and minus mass almost the same and potential energy has the value of $U_T = n(t)U(t)$ at this time.

This value is strong power that can generate inflation in early universe. But roll of this value is very smaller than inflation period in the growth universe(mean distance r is very bigger than initial mean distance r_0) and because of our universe have positive potential energy, so its doing expansion now. Considering of pair annihilation, potential energy of universe can under the zero again.

7.Result of observing WAMP

From the results of observing WAMP at the beginning of universe, the existence of temperature deviation [8] has an influence on cosmic background radiation owing to non-uniformity of matter caused by the existence of minus mass, or the gravity that minus mass works on time and space. Accordingly, if we try to interpret the result of observing WMAP with minus mass, we can find the basis of minus mass.

8.Simulation of the aspect of colliding with Bullet Cluster

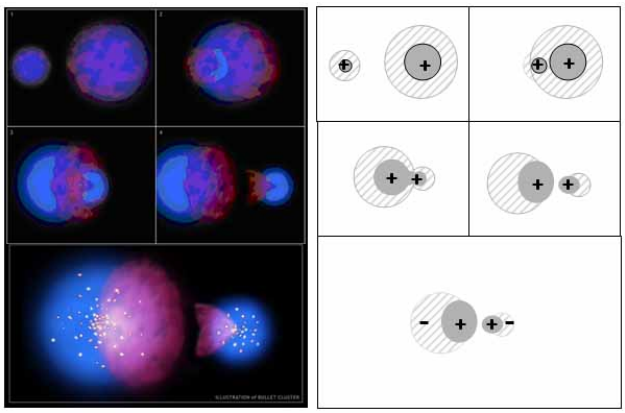

Figure 23: Collision of bullet cluster. We can see that general matters are close to each other, and dark matters are on the far side.

1)Plus mass, plus mass : attractive
2)Minus mass, minus mass : repulsive
3)Massive plus mass, minus mass : attractive
4)Result : At least, from 3 characteristics above, we can predict that 1) is arranged on the close side and 2) is arranged on the far side. Can we explain the phenomenon [5] that dark matter is arranged on the far side and visible positive matter is arranged on the close side in Fig.23 with other dark matters? Minus mass shows the result matched with the phenomena, and it means that it is necessary to perform more strict simulation with minus mass.

9.We must observe the exterior of galaxy, not its interior to observe dark matter(minus mass)

Most of observation equipments focus on the interior including galaxy core in exploring dark matter, but according to the hypothesis of minus mass, dark matter made up with minus mass exists out of galaxy, so we must observe the exterior of galaxy to find the evidence of dark matter.

10. Investigation of minus mass in accelerator

There is the possibility that minus mass is born in accelerator, so it is necessary to consider minus mass with opening the possibility of minus mass while performing an experiment with accelerator.

VI. Conculsion

If minus energy and plus energy were born together at the time of Big Bang, then minus energy may create minus mass, and plus energy may exist in the universe at the state of plus energy such as plus mass, electromagnetic wave, etc. Newton's law of motion can explain that plus mass formed massive plus mass structure such as planet or galaxy, minus mass was disappeared when meeting plus mass near massive plus mass structure at the period of galaxy formation, but minus mass born at the beginning of universe still exists out of galaxy, this minus mass can perform a role of centripetal force that binding galaxy in galaxy cluster, or stars in individual galaxy, and repulsion and dark energy accelerate plus mass in the direction of cosmic expansion.

The existence of minus mass seems to satisfy evenly all characteristics of existing dark matter and dark energy such as the effect of centripetal force in galaxy or galaxy cluster, the mass effect proportional to distance r, repulsion required for cosmic expansion, dark energy that has plus value, element only for gravity gravitational interaction, low interaction between dark matters when cluster of galaxies collision, decelerating expansion at the first half of universe and current accelerating expansion, formation of void and galaxy, and difficulty in observation, so it is necessary to perform more experiments focusing more strict theoretical calculation and observation of minus mass.

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