Size and Expansion of the Universe in Zero Energy Universe (Logical defenses for the Model "We are living in a black hole")

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We can propose two models as an example for Zero Energy Universe Model. In this paper, we research that the total energy of the universe is zero, matters have a positive energy, and only gravitational potential energy is considered as a negative energy to offset this positive energy. In this model, to establish energy conservation law while the universe is expanding, energy needs to be increased, which increases R_{gs} or R_B of the universe. If a newly appeared energy has antigravity or negative pressure characteristics, it can be used as the model that can account for dark energy. There exists a zone that has a uniform energy density within R_{gs} due to the presence of gravitational potential energy with negative values. Base on this, I estimated the current size of the universe. And the model that I propose can solve some problems that the model "the universe is a black hole" had.

I. Introduction

I advocated the Zero Energy Universe (ZEU) model that negative energy and positive energy were pair produced, in the preceding studies. [1–4] We can propose two models as an example for ZEU model.

Model-1.

$$E_T = 0 = (+E) + (-E) = \sum +mc^2 + \sum -\frac{Gm_i m_j}{r_{ij}} = 0 \tag{1}$$

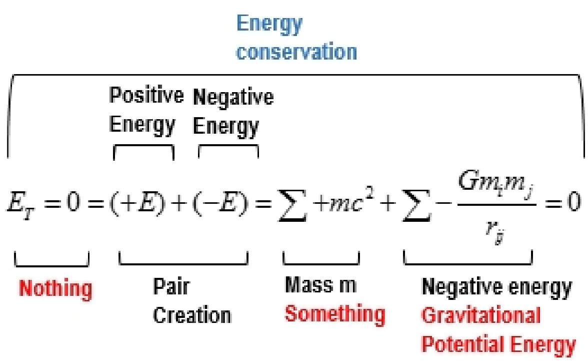

Figure 1: Zero Energy Universe Model-1. Model that considers gravitational potential energy only as negative energy.

"$E_T = 0$" represents "Nothing" state. (State equation of the Nothing))

Mass appears in "$\sum +mc^2$" stage, which suggests the state of "Something".

In other words, "Nothing" produces a negative energy of the same size as that of a positive energy and can produce "Something" while keeping the state of "nothing" in the entire process ("$E_T = 0$" is kept both in the beginning of and in the end of the process).

Model-1 is a model that the total energy of the universe is zero, matters have a positive energy, and only gravitational potential energy is considered as a negative energy to offset this positive energy.

Model-2.

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

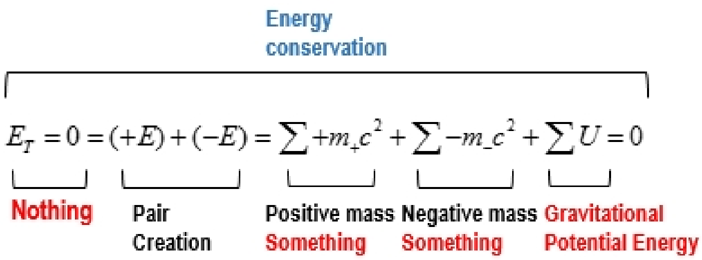

Figure 2: Zero Energy Universe model-2. [1–4] Model that considers negative mass as negative energy. Simply put, negative mass indicates that energy can be locally distributed and has characteristics as particle.

"$E_T = 0$" represents "Nothing" state.

Mass appears in "$\sum +m_+c^2$" and "$\sum -m_-c^2$" stage, which suggests the state of "Something".

In other words,"Nothing" can produce "Something" while being preserved in the entire process, by pair creating positive mass and negative mass.

Model-2 is also a model that the total energy of the universe is zero, there exist positive energy and negative energy in matter or energy, and gravitational potential energy that both energies produce has both + and -.

The above model has a philosophy of the birth of the universe and hints at the birth of the universe.

It changes, but does not change!

It changes not to change!

Stephen Hawking, Alan Guth, and Alexander Vilenkin are the pioneers who advocated that positive mass energy could be offset by gravitational potential energy only, like in Model-1. [5]

However, Hawking and Guth did not advocate ZEU because they introduced the energy state as false vacuum before Big Bang. Hawking also argued that zero energy state could be maintained when mass energy and gravitational potential energy were offset each other at the inflation period only. [5]

Anyway, let us assume that the gravitational potential energy with negative values like in Model-1 offsets the mass energy completely and in addition to this, energy conservation law is still valid!

II. Size of the Universe from the ZEU Model

1. Black hole does not have a singularity and there exists a zone that has a uniform density within the black hole. [4]

What was contained in the previous study [4] is copied here as it is one of the key points for this inference.

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1-1. *Gravitational self-energy or Gravitational binding energy* [6]

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.

$M = \sum dM$

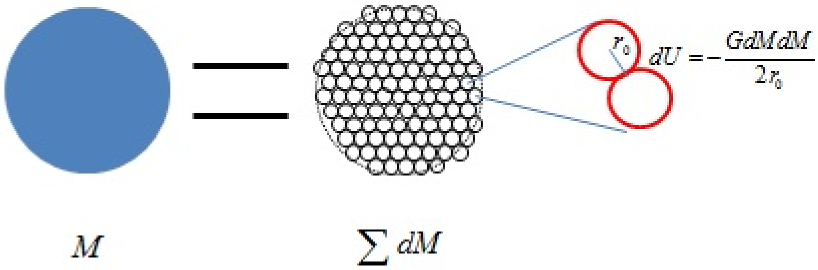

Figure 3: *Since all mass M is a set of infinitesimal mass dMs and each dM is gravitational source, too, there exists gravitational potential energy among each of dMs. Generally, gravitational potential energy by infinitesimal mass that consists of an object itself is reflected on the mass of the object 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*)

1-2. *For black hole or singularity, never fail to consider gravitational self-energy*

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

$$U_{gs} = |-\frac{3}{5}\frac{GM^2}{R_{gs}}| = Mc^2 \quad (3)$$

$$R_{gs} = \frac{3}{5}\frac{GM}{c^2} \quad (4)$$

This equation means that if infinitesimal 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_B, the radius of Schwarzschild black hole,

$$R_{gs} = \frac{3}{5}\frac{GM}{c^2} < R_B = \frac{2GM}{c^2} \quad (5)$$

$$R_{gs} = 0.3R_B \quad (6)$$

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 $0.3R_B$, a 30% level of the black hole radius.

Since this value is on a level not negligible against the size of black hole, we should never fail to consider "gravitational self-energy" for case of black hole.

1-3. *Black hole doesn't have singularity.*

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 $0.3R_B$ 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.

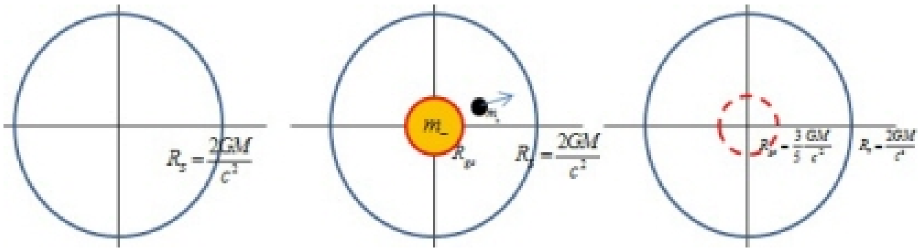

Figure 4: *Considering gravitational potential energy for black hole, the area of within R_{gs} has gravitational self-energy of negative value, which is larger than mass energy of positive value. This area(within R_{gs}) exercises antigravity on all particles entering this area anew, and accordingly prevents all masses from gathering to r=0.*

However, it still can perform the function as black hole because R_{gs} is only 30% of R_B 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_B.

1-4. *Expansion of general relativity*

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.

In the Schwarzschild solution,

$$ds^2 = -(1 - \frac{2GM}{c^2 r})c^2dt^2 + \frac{1}{(1 - \frac{2GM}{c^2 r})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{7}$$

For the sphere with uniform density,

$$-M_{gs} = -\frac{3}{5}\frac{GM^2}{Rc^2} \tag{8}$$

$M \to M + (-M_{gs})$

$$ds^2 = -(1 - \frac{2G(M - M_{gs})}{c^2 r})c^2dt^2 + \frac{1}{(1 - \frac{2G(M-M_{gs})}{c^2 r})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{9}$$

In general, $M \gg M_{gs}$. But we should never fail to consider "gravitational self-energy" for case of black hole.

1)If $M \gg M_{gs}$, we get the equation (7).

2)If $M \ll M_{gs}$,

$$ds^2 \simeq -(1 + \frac{2GM_{gs}}{c^2 r})c^2dt^2 + \frac{1}{(1 + \frac{2GM_{gs}}{c^2 r})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{10}$$

i) $0 \le r < R$

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.*

$$-M_{gs} = -\frac{4\pi r^3}{3}\rho_{gs} \tag{11}$$

$$(1 + \frac{2GM_{gs}}{c^2 r}) = 1 + \frac{2G(\frac{4\pi}{3}r^3\rho_{gs})}{c^2 r} = 1 + \frac{8\pi G\rho_{gs}r^2}{3c^2} \tag{12}$$

$$ds^2 \simeq -(1 + \frac{8\pi G\rho_{gs}r^2}{3c^2})c^2dt^2 + \frac{1}{(1+\frac{8\pi G\rho_{gs}r^2}{3c^2})}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{13}$$

If $r \to 0$,

$$ds^2 \simeq -c^2dt^2 + dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 \tag{14}$$

There is no singularity.

For Schwarzschild black hole, the Kretschmann scalar is,

$$R^{\mu\nu\rho\sigma}R_{\mu\nu\rho\sigma} = \frac{48G^2M^2}{c^4r^6} \tag{15}$$

If $r \to 0$,

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

It does not diverse.

Therefore, black hole doesn't have singularity.
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We should accept universal consensus that the singularity that was born from the general relativity is wrong. Our universal consensus has a problem in singularity and most scholars think that singularity would not exist as physical object. [7] It's because problems can be solved if a new model is presented in the process of solving this singularity issue, like quantum mechanics came from the Ultraviolet Catastrophe [8] in the past.

Waiting for quantum gravity theory to be completed to solve the singularity issue in a black hole is wrong as it was made by our stereotypes.

When there occurred a problem in singular **"point"**, one dimensional idea that problems should be solved from λ, **wavelength that has a little bigger than "point"** was partially acted. Of course, we should try to establish a quantum gravity theory for other reasons.

We can think of a black hole of big size and approach this problem by reducing the mass of this black hole. In other words, we should form a certain internal structure of usual size and apply the experience that we had applied the limit.

$$\lim_{M \to small} R_{gs}$$

If you are still uncomfortable with R_{gs}, think about a black hole with the size 10 billion times bigger than the solar mass! Schwarzschild radius of this black hole is $R_B = 3\times10^{10}km$ and R_{gs} of this black hole $1\times10^{10}km$. **Is it a size that requires quantum mechanics? Is it a high-density state that requires quantum mechanics?**

Black hole of this size is Newtonian mechanics' object and therefore, gravitational potential energy must be considered.

Let's reduce the mass of this black hole gradually and approach three times the solar mass, the smallest size of black hole where stars can be formed! [9]

In case of the smallest black hole by star with three times the solar mass, $R_B = 9km$. R_{gs} of this object is as far as 3km. In other words, **even in a black hole with small size that is made by the contraction of a star, the distribution of internal energy can't be reduced to at least radius 3km.**

Let's think about the black hole with the average energy density of the universe. The movement inside is the energy density that can be explained sufficiently by classical Newtonian mechanics without the help of quantum gravity. Therefore, we must consider gravitational potential energy.

From the above proof, **it is suggested that there exists a zone that has a uniform energy density within R_{gs} and let's use this to estimate the size of the universe.**

2. The source of uniformity and flatness is not inflation but gravitational potential energy.

The mainstream physics assumes inflation [10–12] to explain about the uniformity and flatness of the universe. [9]

However, If the universe starts from the high density state, antigravity exists due to the presence of the gravitational potential energy and thus inevitably the universe expands in uniform density. [2–4]

Also, the universe that was born in high density state does not have a singularity by gravitational collapse, but can be one explanation for the fact that the universe expands.

Therefore, **the uniform density of the universe is likely to be not from inflation field but from gravitational potential energy.** And ZEU model solves the flatness issue fundamentally.

3. Estimation of the size of the universe

Let's obtain the size of the universe that the gravitational potential energy with a negative value offsets the mass energy with a positive value completely, by assuming the uniform distribution of mass In Model-1.

$$E_T = \sum +mc^2 + \sum -\frac{Gm_i m_j}{r_{ij}} = Mc^2 - \frac{3}{5}\frac{GM^2}{R} = 0 \tag{17}$$

To obtain the total of the gravitational potential energy, the gravitational self-energy $\sum -\frac{Gm_i m_j}{r_{ij}} = -\frac{3}{5}\frac{GM^2}{R}$ obtained by assuming the uniform distribution was used. [6]

The kinetic energy of matter is much smaller than mass energy. Also, as the kinetic energy is also a positive energy, it is enough to be considered that this value is included in mass energy term.

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

$$R_{gs} = \sqrt{\frac{5c^2}{4\pi G\rho}} \tag{19}$$

Since we can obtain the critical density $\rho_{c,0}$ of the universe from Friedmann equation,
Use to the Planck data('2013, h=0.678). [13]
$\rho_{c,0} = \frac{3H_0^2}{8\pi G} = 8.64 \times 10^{-27} kgm^{-3}$

$$R_{gs} = \sqrt{\frac{5c^2}{4\pi G\rho}} = 2.49 \times 10^{26} m = 26.3Gly \tag{20}$$

We know that R_{gs} is 30% of the event horizon in Schwarzschild black hole. [3] [4]

$$R_B = \frac{2GM}{c^2} \tag{21}$$

$$R_{gs} = \frac{3}{5}\frac{GM}{c^2} = 0.3R_B \tag{22}$$

If the universe is in a black hole, the black hole will be approx. 3.3 times bigger than R_{gs} obtained from the average density of our universe. Generally, ZEU can't be a black hole. However, if the universe started from a certain positive energy rather than zero, it can be said that our universe exists in a black hole and we are now living a black hole.

When many people think of a black hole, they recall a strong gravity and also have a strong antipathy against the statement that people are living in a black hole.

This is because people do not think deeply of the meaning of formula, but rather are trapped in stereotypes resulting from the knowledge that they had obtained. In other words, they are trapped in this kind of thought that a strong source of gravity that light can't be escaped and a high density celestial body.

However, event horizon $R_B = \frac{2GM}{c^2}$, which defines the size of the black hole contains more. This formula suggests that if the mass of black hole M gets larger, the radius of black hole, i.e. its size gets larger.

The higher the mass of black hole, the smaller the average density of black hole gets.

$$\rho = \frac{3c^2}{8\pi G R^2} \tag{23}$$

Arithmetic indicates that the average density of black hole that is composed of 10^{80} protons drops to the current density level of the universe.

That is, as the larger the mass of black hole, the average energy density gets gradually smaller, the mass of a certain size has the same density as the current density of the universe and thus it doesn't matter at all even when living organisms live in it.

Therefore, **size of the universe is**

$$R_{gs} \le R_U \le R_B \tag{24}$$

$$26.3Gly \le R_U \le 87.7Gly \tag{25}$$

III. Results of the ZEU : Appearance of new energy

1. Appearance of new energy : Dark Energy?

By examining this model, I discovered a possibility to account for the generation of new energy (dark energy?) through this model.

This formula (eq.(1)) contains a new philosophy.

It changes, but does not change! It changes not to change!

Let's think about the meaning of this philosophy more!

From the above formula (eq.(17)), let's assume that the universe expands. Mass energy is fixed and kinetic energy has a positive value or at least 0. However, the larger R, the smaller the negative energy term becomes. Mass term $\sum +mc^2$ is constant, whereas R increases, and so the absolute value of gravitational potential energy $|-\frac{3}{5}\frac{GM^2}{R}|$ gets smaller and finally energy state of 0 is broken.

To look at how equation is valid by unfolding the formula,

$$Mc^2 - \frac{3}{5}\frac{GM^2}{R} = 0 \tag{26}$$

$$M = \frac{5c^2}{3G}R \tag{27}$$

$$M' = \frac{5c^2}{3G}R' \tag{28}$$

In this model, to establish energy conservation law while the universe is expanding, energy needs to be increased, which increases R_{gs} or R_B of the universe.

In other words, we can solve contradiction between "size of a fixed event on the horizon" and "expanding universe", a disadvantage of the model "the universe exists in a black hole.". [14] [15]

If a newly appeared energy has antigravity or negative pressure characteristics, it can be used as the model that can account for dark energy. [16] [17] In this model, newly appeared energy can be defined as newly generated energy to observe the energy conservation law while the universe expands. In this model, dark matters are contained in matters term.

To explain about the characteristics of this model, let's simply define the average energy density of the universe ρ_U as follows.

$$R = \frac{3}{5}\frac{G(\frac{4\pi}{3}R^3\rho_U)}{c^2} \tag{29}$$

$$\rho_U = \rho_m + \rho_\Lambda = \frac{5c^2}{4\pi GR^2} \tag{30}$$

$$\rho_\Lambda(R) = \frac{5c^2}{4\pi GR^2} - \rho_m = \frac{5c^2}{4\pi GR^2}(1 - \frac{R_{m-gs}}{R}) \tag{31}$$

Here, $R_{m-gs} = \frac{3}{5}\frac{GM_m}{c^2}$ represents the size of the universe when mass energy is offset only by the gravitational potential energy of a matter in the past. In other words, it is the size of the universe when dark energy is 0.

If, $R = R_{m-gs}$, $\rho_\Lambda(R = R_{m-gs}) = 0$

At a certain point of time in the past, dark energy was 0 at the point when mass energy and gravitational potential energy of matter are offset completely, or in an equilibrium state. The above formula suggests that as R gets larger, dark energy (new energy) appears to meet the energy conservation law.

As the calculation that includes relativistic term like radiation is rather complex, let's calculate nonrelativistic one in our calculation.

As the density of matter is proportional to $1/R^3$, $R(t) = RR_{m-gs}$

If $R_{m-gs} = 1$ is set, for more intuitive expression,

$$\rho_m(R) = \frac{1}{R^3}(\frac{5c^2}{4\pi G{R_{m-gs}}^2}) \tag{32}$$

$$\rho_\Lambda(R) = \frac{5c^2}{4\pi GR^2}(1 - \frac{R_{m-gs}}{R}) = \frac{R-1}{R^3}(\frac{5c^2}{4\pi G{R_{m-gs}}^2}) \tag{33}$$

$$\rho_\Lambda(R) = (R-1)\rho_m(R) \tag{34}$$

Let's research $R \geq R_{m-gs}$.

This has the following characteristics.

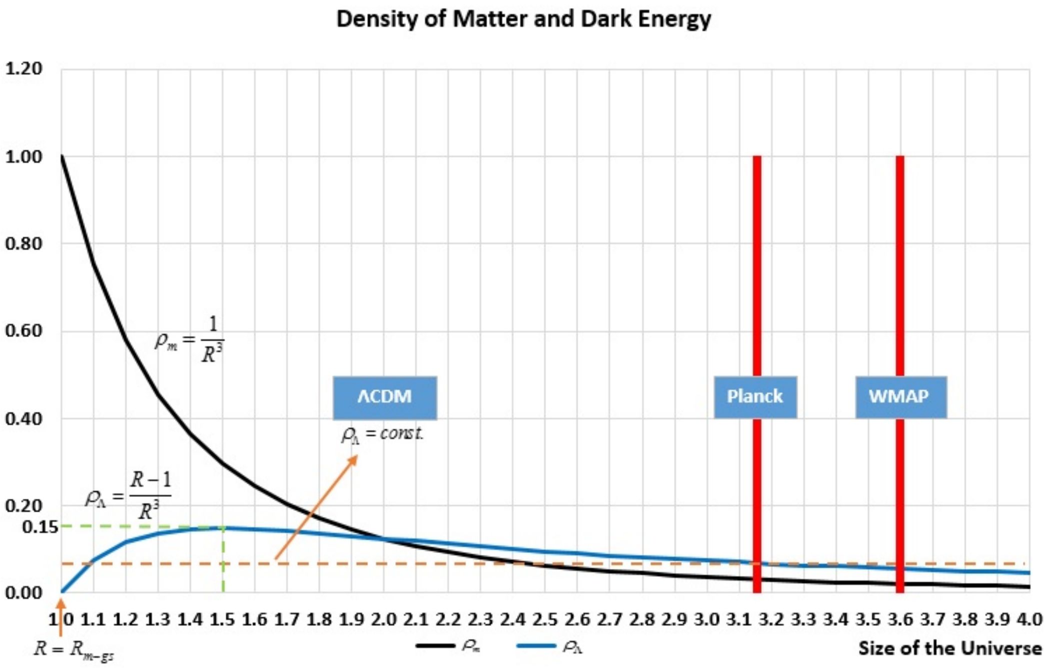

Figure 5: Matters and newly generated energy density ρ_Λ change with the expansion of the universe. In this existing ΛCDM model, the density of dark energy was constant, whereas the density of dark energy in this model follows $(R-1)/R^3$ shaped graph. This graph can be interpreted almost like "ρ_Λ=constant", compared to the density of matter that is proportional to $1/R^3$.

If, $R = R_{m-gs}$, $\rho_\Lambda = 0$
If, $R = \frac{3}{2}R_{m-gs}$, $\frac{R-1}{R^3} = \frac{4}{27} = 0.148$
If, $R = 2R_{m-gs}$, $\rho_\Lambda = \rho_m$
If, $R = 3.15R_{m-gs}$, $\frac{\rho_\Lambda}{\rho_m} = 2.15$

The density of matter is 31.25 times in changes between maximum value and current value, whereas the density of dark energy is 2.64 times in changes between maximum value ad current value. Therefore, it can be found that **this model suggests that the density of dark energy is very closer to observational result that appears to be constant.** [9]

If this ρ_Λ has a repulsive force, it is likely to show the effect of dark energy.
If we obtain pressure from the existing energy conservation equation $\frac{d(R^3\rho)}{dt} = -\frac{P}{c^2}\frac{d(R^3)}{dt}$,
It is

$$P = -\frac{\rho_{m-gs}c^2}{3R^2} \tag{35}$$

But, if substituting this into acceleration equation, it results in Constant Expansion Equation.

$$\frac{d^2R}{dt^2} = -\frac{4}{3}\pi G(\rho + \frac{3P}{c^2})R \tag{36}$$

$$\frac{d^2R}{dt^2} = -\frac{4}{3}\pi G(\rho_m + \rho_\Lambda - \frac{\rho_{m-gs}}{R^2})R = 0 \tag{37}$$

The below is the formula that to obtain the formula in the form of accelerating expansion, pressure remains 0 and energy density ρ_Λ is changed to a negative value to represent a repulsive force.

$$\frac{d^2R}{dt^2} = -\frac{4}{3}\pi G(\rho_m - \rho_\Lambda + 0)R \tag{38}$$

$$\frac{d^2R}{dt^2} = (\frac{R-2}{R^2})\frac{4\pi G\rho_{m-gs}}{3} \tag{39}$$

In this model, dark energy appears after the period of $R = R_{m-gs}$. Therefore, we need to verify the time dependence of dark energy.

IV. What the mainstream physics pointed out about the statements "The Universe is a black hole" or "We are living in a black hole" and counterarguments

I am basically an advocate for ZEU, but by using the above study, can rescue the model "We are living in a black hole" from some difficulties. [14] [15]

If we obtain the Schwarzschild radius of the universe composed of approx. 10^{80} protons from classical mechanics related books, this size obtains a similar value to the Radius of Hubble. It can be inferred from this that our universe is a black hole and we are living in this black hole. Nevertheless, this argument was not acknowledged by the mainstream physics because some important questions were raised about this inference.

Therefore, let's look at what the mainstream physics pointed out about this argument [19–21] and make a counterargument about this!

1) *"a region of space from which nothing, including light, can escape." The implication being that there is a region outside the black hole from which things could at least imagine escaping to. For the universe, there is no such outside region. So at a pretty trivial level, the universe is not a black hole.* [18]

What is pointed out in 1) does not appear reasonable itself, but all objects in the universe existed in the "Universe black hole" from birth, which does not tell us about the presence of external space of "Universe black hole". Also, this point "any particles cannot be escaped from the inside of black hole" rather corresponds to the image of the universe that nothing can be escaped outwardly from the inside of the universe.

2) *You may have noticed that the universe is actually expanding, rather than contracting as you might expect the interior of a black hole to be.* [18]

In this model, if the universe starts from the high density state, antigravity exists due to the presence of the gravitational potential energy and thus inevitably the universe expands in uniform density. [2–4]

According to the argument in this study, to solve the problem that energy conservation is broken by the expansion of the universe, we can make a model that new energy ρ_Λ is created. This suggests that the mass of a black hole like the universe increases. Therefore, the radius of the "Universe black hole" also increases, which may not be contradictory to the expansion of the universe while keeping the model of black hole.

3) *Our universe (according to conventional general relativity) has a singularity in the past, out of which everything emerged, not a singularity in the future into which everything is crashing. We call that singularity the Big Bang,* [18–20]

The argument in 3) is a wrong estimation because it argues that black hole was formed when stars shrank. The universe was born from the inside of black hole from the beginning and it is likely to be born from the area of $R < R_{gs}$ and thus rather corresponds to the image of black hole.

As the negative gravitational potential energy is bigger than the positive mass energy in the area of $R < R_{gs}$, there exists a antigravity effect, and therefore, such an area essentially expands due to repulsive force. This is the very like Big Bang.

4) *Kerr-Newman black holes have a singularity at the center, are surrounded by a vacuum, and have nonzero tidal forces everywhere. The singularity is a point at which the world-lines only extend a finite amount of time into the future. In our universe, we observe that space is not a vacuum, and tidal forces are nearly zero on cosmological distance scales (because the universe is homogeneous on these scales).* [20]

The existing general relativity couldn't provide a uniform distribution of matter in a black hole, but this could be accounted for by the model that I propose. [4]

There exists a repulsive force within the radius of R_{gs} as gravitational potential energy is a negative energy. Therefore, matter distribution is essentially closer to a uniform density within the radius of R_{gs}. [4] This can be a strong explanation for the fact that the universe that we observe has almost a uniform density.

As some key problems about the statement "The Universe is a black hole" can be solved, we need to consider this more seriously and it is also necessary to think that problems occurred can be solved in the process of solving the existing general relativity.

V. Discussion

1. In this model, size of the universe is $R_{gs} \leq R_U \leq R_B$

$$26.3Gly \leq R_U \leq 87.7Gly \tag{40}$$

1)The calculated value in this model depends on Hubble Constant and Critical Density of the universe.

2)The application of general relativity that limits the speed of gravity delivered will influence the size of the universe.

3)The calculated value in the standard model is a result from the assumption used in the standard model. In other words, the expansion of space is assumed and it depends on the relational equation between redshift and distance.

However, **we did not observe the expansion of space directly, but observed Redshift only. If the assumption "Space expands" is wrong, our long distance estimated values should be corrected.** [21] This is the case for when there is a problem in inflation mechanism.

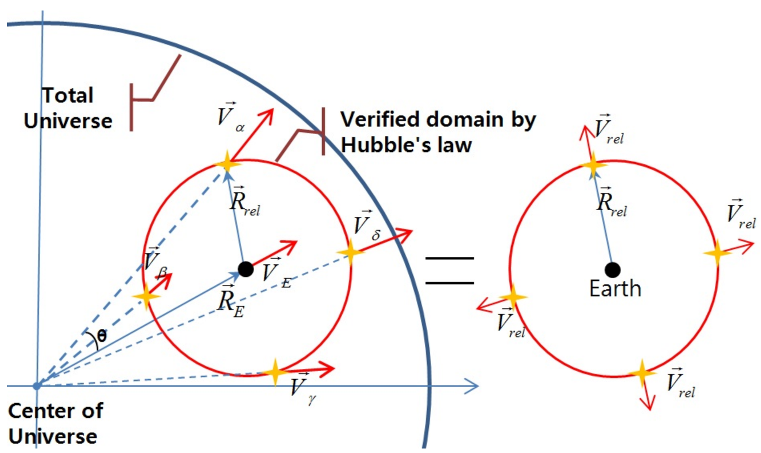

Figure 6: ***Hubble's law doesn't result from the expansion of space, but is a dynamical result from the movement of galaxies in space. Two situations are same.***

Hubble's law isn't a matter only explained by special condition such as "center of the universe" or a new concept that we haven't experienced such as "expansion of space".

Hubble's law is a result of dynamics valid in almost all areas when acceleration is small in the universe.

Maybe this would be a good way of looking at it,[1]

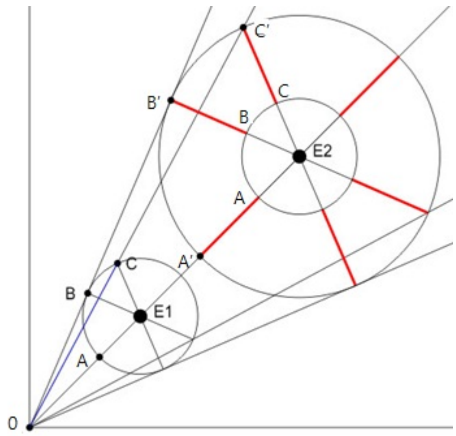

Figure 7: *So that all of the red lines are the same size, the ones where the tangent is the line of expansion too. It's important also that the lengths are proportional, so for example OB/OB' is equal to OC/OC' and OA/OA' since velocity from the center needs to be proportional to distance.*

Therefore, whether this model is right or wrong should not be determined with the estimated values for the current visible universe and the total size of the universe.

For reference, ZEU Model-2 does not limit the size of the universe into the inside of the black hole.

2. Some would be uncomfortable with the statement that energy increases while the universe is expanding.

1) $E_T = 0 = (+E) + (-E) = \sum +mc^2 + \sum -\frac{Gm_i m_j}{r_{ij}} = 0$

What Equation (1) contains just requires the conservation of total energy but does not limit the size of +E. It suggests that it is ok if −E of the same size only exists even if the size of +E changes.

2) This is a phenomenon that suggests that energy conservation law is still valid. Therefore, it is a phenomenon that can occur.

3) We consider Vacuum Energy as source of dark energy in ΛCDM model. [9] [17] Generally, Vacuum Energy increases with the expansion of the universe, which breaks the energy conservation. [9]

If we accept Vacuum Energy that violates energy conservation seriously, it seems that there is no reason for us not to accept the above explanation introduced to keep energy conservation. The above concept is not worse than Vacuum Energy.

4) This model was based on the energy conservation in the perfect zero energy and the entire process. But we will be able to obtain more diverse models if we allow energy conservation law to be broken like ΛCDM model or assume that initial energy is E_0.

[1] I'd once introduced this thesis to Science Community(http://www.scienceforums.net/) and above is an explanation written by a user named Iggy. As the explanation is intuitive, I copy here.

Finally,

– **Gravitational self-energy(Total gravitational potential energy) can solve singularity issue and rescue general relativity that collapses itself.** [4]

– **Gravitational self-energy and R_{gs} guarantee uniform density due to repulsive gravity effect and this can be grounds for the expansion in the early universe and the uniform universe.** [4]

– **As Zero Energy Universe Model is one of the strong models that can be used to explain for the origin of the universe energy, it is necessary to study this model more.**

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