Possible holographic universe, graviton rest mass and dark energy

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It is shown that the particle energy is proportional to its surface area. This surface area dependence of the particle energy extended to the universe scale indicates that our universe is the holographic universe. The obtained equation of E = 12.2047 10^{38} x^2 = ρ_sS is based on the experimental rest mass and radius relation of the proton. This result can be a first evidence of the possible holographic particles and universe based on the experimental data. Also, the graviton is proposed to have the rest mass (m_g) of 3.1872 10^{-31} eV/c^2 and the force range of 10.032 Mpc. The diameter (d = 1.3186 10^{30} m) of the observable universe is obtained. The observed dark energy density is explained in terms of the holographic character of the observable universe. Also, the evolution and origin of the black hole and our universe are newly explained.

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I. INTRODUCTION

The origin of our universe is an open question even though it is thought that it might be from the quantum fluctuation. And it is not very clear what the basic structure of our universe is. The universe is made of the force carrying virtual bosons, the real particles and black holes. The force carrying virtual bosons are allowed under the Heisenberg uncertainty principle. And the real particles like leptons and hadrons should be controlled by the different physics principle. And, the holographic principle has been applied to our universe and black hole based on the entropy. In other words, it has been, theoretically, discussed that the maximum entropy of the black hole proportional to the surface area of its event horizon can be explained by the holographic principle [1,2]. This holographic principle based on the thermodynamic entropy has been extended to explain the whole universe by introducing the cosmological event horizon [3,4,5]. There is no direct experimental evidence for the holographic universe. Therefore, it will be interesting to look for the new physics principle of the virtual and real particles and the evidence of the holographic universe. In the present work, it is shown that the energies (E=m_0c^2) of the particles can be proportional to their surface areas. The obtained equation is E = 12.2047 10^{38} x^2 = ρ_sS. This energy and surface area relation for the particles extended to the universe scale is based on the experimental rest mass and radius relation of the proton. This result can be a first evidence of the possible holographic particles and universe based on the experimental data.

Also, the rest mass of the graviton has been theoretically proposed to be $< 6\ 10^{-34}$ eV [6,7] and $\sim 10^{-32}$ eV [8] based on the possible size (x = 3 10^{26} m) of the observable universe and the gravitational Compton wavelength (x = h/(m_gc)). However, there is no direct experimental evidence of the massive graviton. In the present work, it is shown that the rest mass (m_g) of the graviton is 3.1872 10^{-31} eV/c^2 and its force range (x_r) is 10.032 Mpc based on the experimental rest mass and rms charge radius of the proton [9,10] and the proposed size (diameter = 10 Mpc) of the largest galaxy cluster [11]. Because of the massive graviton, the gravitational potential needs to be changed to U=-(Gm_1m_2)$e^{-m_g r}$/r following the Yukawa force effect. Here, m_g is E_g/c^2. This graviton has the zero charge. Also, the evolution and origin of the black hole and our universe are newly explained as follows.

The virtual particle is decaying to the real particles by expanding from the space size with the radius of x_p to the space size with the radius of x >> x_p. The virtual particles with the energy larger than the Planck range virtual boson are defined as the black holes in Fig. 1. Our universe is originated from one black hole with the huge energy. Because the present universe is filled with the matters, it is thought that the original black hole which was changed to our universe is the matter. And the dark energy and dark matter are explained in terms of the holographic character of the observable universe in the present work.

II. REAL PARTICLES AND VIRTUAL PARTICLES

In Table 1, the energies (E= m_0c^2) of the previously known particles are shown as the function of the possible sizes (radius, x (m)) of these particles by using the equation of E(eV) = 12.2047 10^{38} x^2 = ρ_sS. Here S is the surface area of S = $4\pi x^2$ (m^2) and ρ_s is the constant surface energy density of ρ_s = E/S = 0.97122 10^{38} eV/m^2 which is the same as ρ_s^p= E_p/S_p. Here, p means Planck. The equation of E(eV) = 12.2047 10^{38} x^2 is obtained from the measured proton size (rms charge radius: 8.768(69) 10^{-16} m) and proton energy (E=938.27 10^6 eV) [9]. In Table 2, the energies (E= m_0c^2) of the particles are shown as the function of the possible sizes (radius, x (m)) of the particles from the equation of E(eV) = 1.3920 10^{54} x^3 = ρ_vV. Here, V is the spherical volume of V =

TABLE I: Energies (E= m_0c^2) of the fermions are shown as the function of the possible sizes (radius, x (m)) of the particles from the equation of E = 12.2047 10^{38} x^2 = ρ_sS. Here S is the surface area of S = $4\pi x^2$ (m^2) and ρ_s is the constant surface energy density of ρ_s = E/S = 0.97122 10^{38} eV/m^2. The equation of E = 12.2047 10^{38} x^2 is obtained from the measured proton size (rms charge radius: 8.768(69) 10^{-16} m) and proton energy (E=938.27 10^6 eV) [9].

x (m)	E (eV)	particles
8.768(69) 10^{-16}	938.27 10^6	p
2.862 10^{-22}	(10^{-4})	ν_e, ν_μ, ν_τ
2.046 10^{-17}	0.511 10^6	e
2.943 10^{-16}	105.7 10^6	μ
1.207 10^{-15}	1.777 10^9	τ
4.434 10^{-17}	2.4 10^6	u
6.271 10^{-17}	4.8 10^6	d
2.919 10^{-16}	104 10^6	s
1.020 10^{-15}	1.27 10^9	c
1.855 10^{-15}	4.2 10^9	b
1.184 10^{-14}	171.2 10^9	t
1.616 10^{-35}	3.1872 10^{-31}	Planck size particle

TABLE II: Energies (E= m_0c^2) of the fermions are shown as the function of the possible sizes (radius, x (m)) of the particles from the equation of E = 1.3920 10^{54} x^3 = ρ_vV. Here V is the spherical volume of V = $4\pi x^3/3$ (m^3) and ρ_v is the constant surface energy density of ρ_v = E/V = 3.3231 10^{53} eV/m^3. The equation of E = 1.3920 10^{54} x^3 is obtained from the measured proton size (rms charge radius: 8.768(69) 10^{-16} m) and proton energy (E=938.27 10^6 eV) [9].

x (m)	E (eV)	particles
8.768(69) 10^{-16}	938.27 10^6	p
4.157 10^{-20}	(10^{-4})	ν_e, ν_μ, ν_τ
7.160 10^{-17}	0.511 10^6	e
4.235 10^{-16}	105.7 10^6	μ
1.085 10^{-15}	1.777 10^9	τ
1.199 10^{-16}	2.4 10^6	u
1.511 10^{-16}	4.8 10^6	d
4.212 10^{-16}	104 10^6	s
9.699 10^{-16}	1.27 10^9	c
1.445 10^{-15}	4.2 10^9	b
4.973 10^{-15}	171.2 10^9	t
1.616 10^{-35}	5.8744 10^{-51}	Planck size particle

$4\pi x^3/3$ and ρ_v is the constant volume energy density of ρ_v = E/V = 3.3231 10^{53} eV/m^3. The equation of E(eV) = 1.3920 10^{54} x^3 is obtained from the measured proton size (charge radius: 8.768(69) 10^{-16} m) and proton energy (E=938.27 10^6 eV) [9]. The energy density of ρ_v = 1.3920 10^{54} eV/m^3 obtained in Table 2 is not the same to the critical energy density of ρ_v = 5.5534 10^9 eV/m^3. Therefore, the equation of E = 1.3920 10^{54} x^3 = ρ_vV cannot explain the energy density of the observable universe [15]. But the equation of E = 12.2047 10^{38} x^2 = ρ_sS obtained in Table 1 can explain the energy density of the observable universe [15] with the diameter of d = 1.3186 10^{30} m as explained in the section IV.

The particle size prediction from these equations is within the reasonable range for the known particles in Tables 1 and 2. One big difference is for the energy of the Planck size particle. The energy of the Planck size particle is 3.1872 10^{-31} eV in Table 1 and 5.8744 10^{-51} eV in Table 2. Planck size particle is the minimum size of the observable particle. The virtual particles are predicted only by the uncertainty principle of $\Delta E \Delta t = \hbar/2$. In the present work, it is assumed that this virtual particle is fluctuating between nothing with x=0 and the virtual particle with the Planck size (x=x_p) in Fig. 1. Here x is the particle radius. Then all of the virtual particles are proposed to have the Planck size and different energy density in Fig. 1 of the present work.

The Planck range of the virtual force carrying boson is x_r = $2x_p$ = 2 1.616 10^{-35} m = 3.232 10^{-35} m. From the equation of E=9.866 10^{-8} / x_r (eV) obtained from the uncertainty principle of $\Delta E \Delta t = \hbar/2$, the Planck range boson has the energy of 3.0526 10^{27} eV. The Planck energy (1.2209 10^{28} eV) of the Planck range boson has been calculated from E= $c^2\sqrt{\frac{\hbar c}{G}}$. Another reduced Planck energy (2.435 10^{27} eV) of the Planck range boson has been calculated from E= $c^2\sqrt{\frac{\hbar c}{8\pi G}}$. The energy (E = 3.0526 10^{27} eV) of the present Planck range boson obtained from the uncertainty principle is consistent with the reduced Planck energy (2.435 10^{27} eV) and the Planck energy (1.2209 10^{28} eV).

In Fig. 1, the virtual particles with S_p = E/ρ_s = constant are divided as the bosons and black holes, and the real particles with ρ_s^p = E/S = constant are divided into the particles and universes. Here, universes mean the real particles which have the internal virtual particles. These internal virtual particles increase the energy and space area of the universe which causes the constant or accelerated expansion of the universe like our present universe.

III. MASSIVE GRAVITON AND PLANCK SIZE PARTICLE

The minimum observable size of the real particles is the Planck size of x_p = 1.616 10^{-35} m. Then the energy of this Planck size real particle is 3.1872 10^{-31} eV from the equation of E = 12.2047 10^{38} x^2 = ρ_sS in Table 1 and 5.8744 10^{-51} eV from the equation of E = 1.3920 10^{54} x^3 = ρ_vV in Table 2. Also, the observable size of the force carrying boson always is the Planck size of x_p = 1.616 10^{-35} m. The energy of the force carrying boson is decreased with the increasing of the force range (x_r). Because the photon and gluon have the zero rest mass, the minimum energy of the force carrying boson is the graviton energy if the graviton has the rest mass. The gravitational force between two matters is explained by the force carrying graviton. The largest gravitational system is known as the galaxy cluster which has the largest proposed diameter of 10 Mpc = 3.08568 10^{23} m [11]. Therefore, in the present work, the gravitational force range is taken as the x_r = 3.08568 10^{23} m = 10 Mpc. Then, from the equations of E = 9.866 $10^{-8}/x_r$ (eV) (x_r: m) and m = E/c^2 obtained from uncertainty principle of $\Delta E \Delta t = \hbar/2$, the graviton has the mass (m_g) of 3.19735 10^{-31} eV/c^2. The energy (3.19735 10^{-31} eV) of the proposed graviton is remarkably consistent with the energy (3.1872 10^{-31} eV) of the Planck size real particle obtained from the equation of E = 12.2047 10^{38} $x^2 = \rho_s S$ in Table 1 but not with the energy (5.8744 10^{-51} eV) of the Planck size real particle obtained from the equation of E = 1.3920 10^{54} $x^3 = \rho_v V$ in Table 2. Inversely, if the graviton energy is the energy (3.1872 10^{-31} eV) of the Planck size real particle, the obtained force range is 3.0955 10^{23} m = 10.032 Mpc which is remarkably consistent with the proposed diameter (10 Mpc) of the largest galaxy cluster [11]. In the present work, 3.1872 10^{-31} eV/c^2 and 3.0955 10^{23} m are taken as the graviton rest mass and force range, respectively. Because of the massive graviton, the gravitational potential needs to be changed to U=-(Gm_1m_2)$e^{-m_g r}$/r following the Yukawa force effect. Here, mg is E_g/c^2. This graviton has the zero charge. Therefore, the equation of E = 12.2047 10^{38} $x^2 = \rho_s S$ gives the reasonable prediction of the graviton mass. This surface area dependence of the particle energy extended to the universe scale indicates that our universe can be described in terms of the holographic principle. Also, the equation of E = 1.3920 10^{54} $x^3 = \rho_v V$ cannot explain the energy density of the observable universe as explained in the following section. But the equation of E = 12.2047 10^{38} $x^2 = \rho_s S$ obtained in Table 1 can explain the energy density of the observable universe with the diameter of d=1.3186 10^{30} m as explained in the following section. Therefore, this supports the surface area dependence of the particle energy extended to the universe scale as shown in the equation of E = 12.2047 10^{38} $x^2 = \rho_s S$.

IV. BLACK HOLE, DARK ENERGY AND THE UNIVERSE

As shown in Fig. 1, the minimum virtual particle is proposed as the graviton. The minimum real particle with the Planck size is identical to this graviton. The maximum force carrying virtual particle has the force range of $2x_p$ and the energy of 3.0526 10^{27} eV. Generally, the virtual particle is decaying to the real particles by expanding from the space size with the radius of x_p to the space size with the radius of x >> x_p. This space transition is a kind of the small space inflation compared with the largest space inflation of our universe. It is called, alternatively, as the particle transition of the virtual boson in the present work. The radii of the leptons, quarks and hadrons are much larger than the Planck lengths (x_p) of Z and W bosons.

The virtual particles with the energy larger than the Planck range virtual boson are defined as the black holes as shown in Fig. 1, in the present work. The gravitational event horizon defined as the Schwarchild radius for the non-rotating black hole [13] should be larger than the radius (Planck length, x_p) of these black holes. These black holes based on the quantum fluctuations can be formed from nothing and can disappear to nothing [12]. Also, some of them can be transformed to the real particle by the space inflation which is defined as the huge space expansion in a short time. Our universe is originated from the inflation of one black hole with the huge energy in Fig. 1 [14]. Generally the black hole can have the charge like the W^- boson and can be the matter or antimatter virtual particle. Because the present universe is filled with the matters, it is thought that the original black hole which was changed to our universe is the matter.

After one black hole is changed to the real particle which is our universe, many virtual particles of the bosons and black holes with the energy smaller than the original universe are created inside our universe. Those virtual particles are matters because the original universe is the matter. These virtual particles include the virtual bosons shown in Fig. 1 and the virtual leptons, quarks and hadrons not shown in Fig. 1, which are created from nothing under the uncertainty principle. The real particles of the leptons, quarks and hadrons with the large size of x >>x_p shown in Fig. 1 are created from the particle transition of the corresponding virtual particles. These particles are the matters in our universe. Of course, the matters and antimatters produced by the pair production of the particle and antiparticle from the photons and the background fluctuations could be annihilated completely. Only the matters originated from the virtual particles have survived so far inside the present universe. This can explain why the matters are dominated over the antimatters inside our present universe. Conceptually, many black holes were made inside our universe and some of these black holes become many smaller universes inside the main universe. It supports the multiverse concept. The new real particles are made by the transition and decay from some of the new virtual particles including the new black holes to the real particles. Then the energy of the universe is increased. From the relation of E = 12.2047 10^{38} $x^2 = \rho_s S$ with the constant ρ_s, the surface area and space volume of our universe should be expanded. As the number of the virtual particles in the fixed volume to change to the real particles is increasing, the space expansion of the universe is accelerated. This is the origin of the dark energy. In Fig. 1, our observable universe has the diameter of d = 2x. The energy (E) of our observable universe is E = ρ_v(energy)$4\pi x^3/3$ = $\rho_s 4\pi x^2$. The mean energy density (critical energy density) of our observable universe is ρ_v = 9.9 10^{-30} gram/cc [15]. Then, ρ_v(energy) = 5.5534 10^3 eV/cc = 5.5534 10^9 eV/m^3 = $\rho_v c^2$. Therefore, the diameter of the observable universe is d = 2x = ($6\rho_s$)/(ρ_v(energy)) = (6 12.2047 10^{38})/(5.5534 10^9) = 1.3186 10^{30} m. The observed dark energy density of ρ_Λ(energy) = 0.714ρ_v(energy) =7.0686 10^{-30} gram/cc [15] is defined for this observable universe. This observed dark energy density can be explained in terms of the holographic character of the observable uni-

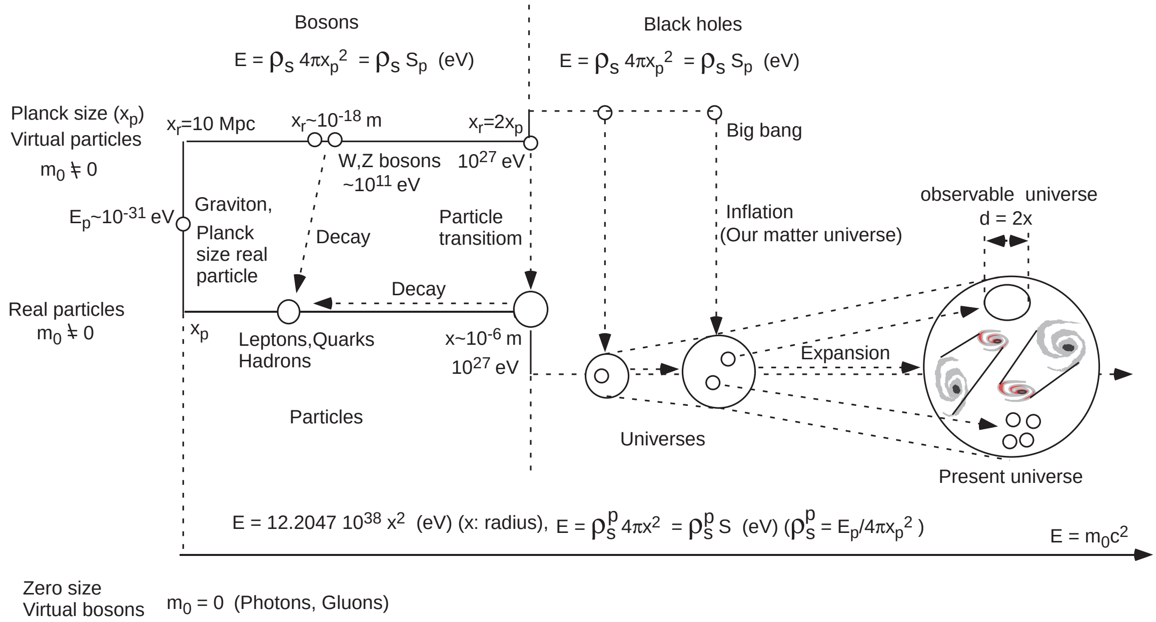

FIG. 1: Graviton, holographic particles and universe.

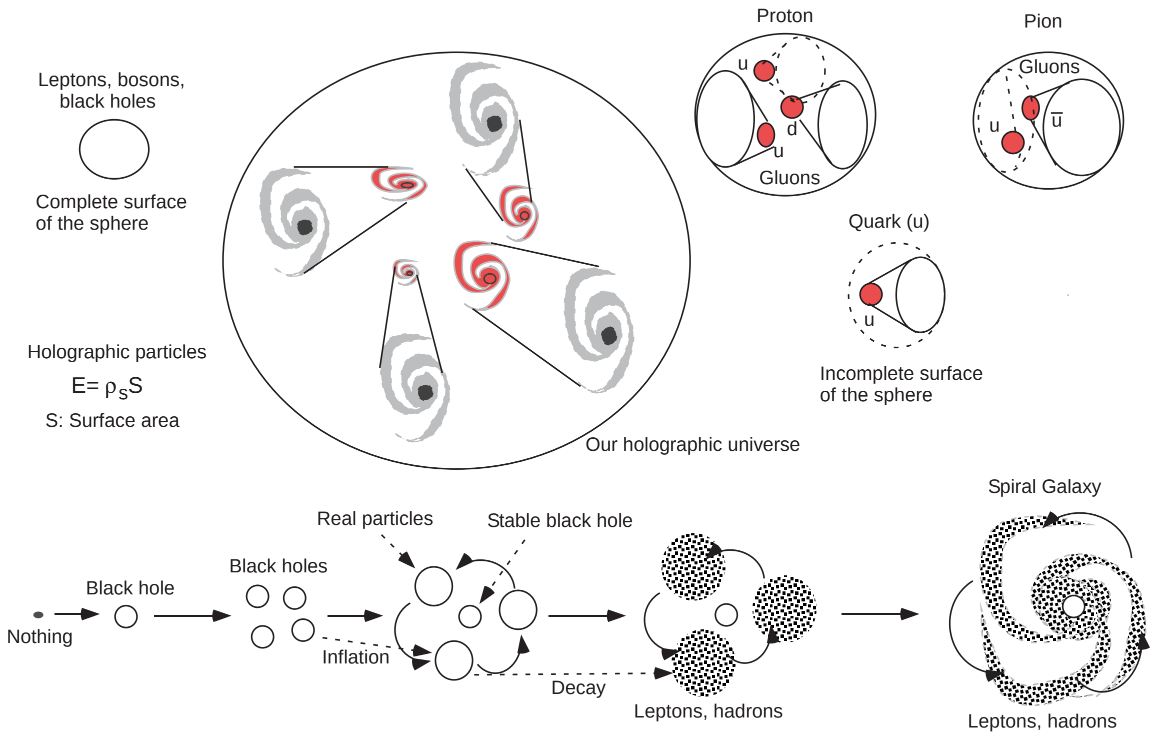

FIG. 2: Holographic particles of the proton, meson and our universe, and an example of the spiral galaxy formation are shown.

verse. However, the energy density of ρ_v = 1.3920 10^{54} eV/m^3 obtained in Table 2 is not the same to the critical energy density of ρ_v = 5.5534 10^9 eV/m^3. Therefore, the equation of E = 1.3920 10^{54} x^3 = ρ_vV cannot explain the energy density of the observable universe [15]. But the equation of E = 12.2047 10^{38} x^2 = ρ_sS obtained in Table 1 can explain the energy density of the observable universe [15] with the diameter of d = 1.3186 10^{30} m. This supports that our universe is the holographic universe. And the graviton has the rest mass and exists only around the matters as the gravitational force carrying bosons. Therefore, it is proposed that theses gravitons are the good candidates of the dark matters around the galaxy.

And the black hole created inside the main universe could decay to several smaller black holes with the angular momenta as shown in Fig. 2. In case, smaller black holes could rotate around the biggest black hole of them. The biggest black hole becomes stable at the gravitational center of the system by the gravitational interactions. Then, smaller black holes could decay to the smaller force carrying virtual particles and smaller real particles which could decay to the leptons and hadrons. This is the origin of the spiral galaxy formation like our milky-way galaxy as shown in Fig. 2. Other shaped galaxies can be explained in terms of the similar black hole decay.

V. SUMMARY

In summary, the virtual particles with $S_p = E/\rho_s =$ constant are divided as the bosons and black holes, and the real particles with $\rho_s^p = E/S =$ constant are divided into the particles and universes. Here, universes mean the real particles which have the internal virtual particles. These internal virtual particles increase the energy and space area of the universe which causes the constant or accelerated expansion of the universe like our present universe. The holographic principle is applied to the particles and universe based on the energy. In other words, it is shown that the particle energy is proportional to its surface area. The obtained equation is E(eV) = 12.2047 10^{38} $x^2 = \rho_s S$. Here S is the surface area of $S = 4\pi x^2$ (m^2) and ρ_s is the constant surface energy density of ρ_s = E/S = 0.97122 10^{38} eV/m^2. The equation of E(eV) = 12.2047 10^{38} x^2 is obtained from the measured proton size (charge radius: 8.768(69) 10^{-16} m) and proton energy (E=938.27 10^6 eV). In the present work, it is concluded that the graviton is the Planck size real particle and has the force range of 10.032 Mpc in Fig. 1. The graviton has the rest mass (m_g) of 3.1872 10^{-31} eV/c^2. This result might be the rare evidence of the holographic universe and holographic particles as explained simply in Fig. 2 of the present work.

Generally, the virtual particles are decaying to the real particles by expanding from the space size with the radius of x_p to the space size with the radius of $x >> x_p$. This space transition is a kind of the small space inflation compared with the largest space inflation of our universe. It is called as the particle transition of the virtual boson in the present work, too. The virtual particles with the energy larger than the Planck range virtual boson are defined as the black holes as shown in Fig. 1. These black holes based on the quantum fluctuations can be formed from nothing and can disappear to nothing. Also, some of them can be transformed to the real particle by the space inflation which is defined as the huge space expansion in a short time. Our universe is originated from one black hole with the huge energy. Because the present universe is filled with the matters, it is thought that the original black hole which was changed to our universe is the matter. As the number of the virtual particles in the fixed volume to change to the real particles is increasing, the space expansion of the universe is accelerated. This is the origin of the dark energy. The diameter of the observable universe is $d = 2x = (6\rho_s)/(\rho_v(\text{energy}))$ = 1.3186 10^{30} m. The dark energy density of $\rho_\Lambda(\text{energy}) = 0.714\rho_v(\text{energy})$ is defined for this observable universe. The observed dark energy density is explained in terms of the holographic character of the observable universe. The graviton has the non-zero rest mass and exists only around the matters as the gravitational force carrying bosons. Therefore, it is proposed that theses gravitons are the dark matters around the galaxy. The matters originated from the virtual particles have survived so far inside the present universe. This can explain why the matters are dominated over the antimatters inside our present universe.

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