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Article

Negative Matter of Unified Dark Matter and Dark Energy and Its Observed Ways in the Milky Way, and Possible Mechanism of Missing Antimatter

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Abstract: Based on Dirac negative energy, Einstein mass-energy relation and principle of equivalence, we propose the negative matter as the simplest model of unified dark matter and dark energy. All theories are known, only mass includes positive and negative. Because there is repulsion between positive matter and negative matter, so which is invisible dark matter, and repulsion as dark energy. It may explain many phenomena of dark matter and dark energy. We derive that the rotational velocity of galaxy is approximate constant, and an evolutional ratio between total matter and usual matter from 1 to present 11.82 or 7.88. We calculate the accelerated expansion at 9.76 billion years. Further, the mechanism of inflation is origin of positive-negative matters created from nothing, whose expansion is exponential due to strong interactions at small microscopic scales. We propose specifically some possible ways on observe dark matter in the Milky Way. Many observatories should be able to observe these results. Two evolutional processes from inflation to the matter-dominated universe produce the positive-negative matters, and opposite matters, respectively. Such we may propose a mechanism of missing antimatter when the attraction of the positive and negative charge is greater than the repulsion of positive and negative masses. The negative matter as a candidate of unified dark matter and dark energy is not only the simplest, and is calculable, observable and testable, and may be changed and developed.

Keywords: dark matter, dark energy, negative matter, mass-energy relation, principle of equivalence, unification, calculation, observation.

1. Introduction

Dark matter and dark energy as everyone knows are the greatest mysteries in astronomy and total physics. General hypothesis is that dark matter and dark energy are two different concepts.

Since 1970 to 1978, Rubin, et al., confirmed the existence of dark matter for ten spiral galaxies [1]. Further, the dark matter in the Galaxy, in group of galaxies and cluster of galaxies, in the universe, is confirmed by the mass-to-light ratio and the galactic rotational curves, etc [2].

Physicists have proposed many models on dark matter and dark energy, for example, weakly interacting massive particles (WIMPs), Quintessence, k-essence, Phantom, cosmic string, axion, brane cosmology, scaling dark energy, Holographic dark energy and so on. Recently, ultralight dark matter (ULDM) becomes a new important candidate [3,4].

For new data [5,6], usual visible matter is 4.84%, dark matter is 25.96%, and dark energy is 69.2%. But, so far many models on dark matter and dark energy are not testability.

In this paper, we propose three basic principles of the negative matter as a candidate unified dark matter and dark energy, and derive some corresponding calculate results, and propose observed ways in the Milky Way and possible mechanism of missing antimatter.

2. Three Basic Principles of Negative Matter as Unified Dark Matter-Energy

Dark matter and dark energy are the results of astronomical observations. They are amazing, but are not mysterious. Some believe that dark energy distributes uniformly in the whole space, and throughout the universe, even to us. Because dark matter is 25.96%, and dark energy is 69.2% in Universe [5.6], as long as there is some dark matter or dark energy in the solar system, general relativity, even Newtonian's gravity theory cannot be so accurate, therefore, there are not necessarily dark matter and dark energy in the solar system. Recently, astronomers find more galaxies in the Universe without any dark matter. Guo, et al. reported 19 dwarf galaxies that could consist mainly of baryons, and provided observational evidence that could challenge the formation theory of low-mass galaxies within the framework of standard cosmology [7].

In 1928 Dirac predicted anti-particles and the negative energy state from his equation, and he emphasized: “we cannot ignore the negative energy states” [8]. In order to prevent to jump continuously from positive energy state to negative energy state in the quantum theories, and keep the stability of world, Dirac proposed that as long as suppose that all the states of negative energy are occupied except perhaps a few of small velocity. The vacuum of the realistic world has already been filling with all negative energy states, such the Pauli exclusion principle will come into play and prevent more than one electron going into any one state, and avoid this jumping difficulty. It is namely the well-known Dirac

negative energy sea and whose vacancy or hole is an anti-particle (or opposite particle). From this the annihilation and creation between positive and opposite particles may be predicted. There is exact description in *The Principles of Quantum Mechanics* [9]. But, it prevent only jump of fermions, but cannot be applied to bosons. Therefore, the stability problem exists still. In fact, the negative energy state appears in all relativity theories as $E=\pm\sqrt{p^2c^2+m^2c^4}$, even also in the classical theory.

I. Based on Dirac negative energy state, from 2007 we proposed that the negative matter may unify dark matter and dark energy [10-16], in which the anti-(opposite) matter and the negative matter are different. The anti-matter is that some properties of matter are opposite, for instance, charge, baryon number, lepton number, strangeness number and so on, but their masses and total energy are still positive. These particles include positron and various anti-particles. The existence of these particles is already verified. Both positive and opposite matters meet to annihilate to photons with conservation of energy and zero-charge. A key of the negative matter is negative mass. According to the gravitational force:

$$F=-\frac{G}{r^2}M_1M_2, \qquad (1)$$

there is still gravitational force between negative-negative matters, but it is universal repulsive force between the positive and negative matters. Therefore, the positive and negative matters are two regions of topological separation in general case by different interactions [10-16].

Based on $M\to M_+-M_-$ and Eq.(1), all theories are all known. The positive and negative matters are two regions of topological separation in general case by different interactions, so the negative matter is invisible dark matter. Repulsion between positive matter and negative matter shows dark energy. This is the simplest candidate of dark matter, and can be unified dark energy, and may explain many phenomena of dark matter and dark energy [10-16]. The negative matter should be a necessary development of Dirac theory.

II. According to the principle of equivalence in general relativity, inertial mass and gravitational mass must be equal always. Based on Eq.(1), there are only three cases: positive and positive matters, positive and negative matters, negative and negative matters [10,11]. But, for negative mass Bondi [17] proposed three kinds of mass: inertial, passive gravitational, and active gravitational mass, and there are four cases. Such Bondi believes that the positive body will attract the negative one, etc. It is a fallacy with contradictions.

III. According to Einstein mass-energy relation $E=mc^2$, dark matter and dark energy should be unified, and it agrees with Occam's Razor [14].

We found that some proofs of the positive mass theorem have all certain premises: an isolated gravitational system and infinite space, but both are all impossible. Therefore, the negative matter cannot

be restricted [15]. Further, we discussed some simple estimations of the positive matter theorem, which agree from astronomy to particles [15].

In the modern cosmology [18,19], for a radiation-dominated universe of the big-bang cosmology, the total energy of usual matter is mainly the positive energy of photon Mc^2. When the evolutional process from inflation and radiation-dominated universe to the matter-dominated universe, the known total energy of usual baryon matter of non-relativity is:

$$Mc^2 - \frac{GmM}{r}. \qquad (2)$$

The positive mass theorem is simplified to $Mc^2 > GMm/r$, i.e., $c^2 > Gm/r$. This constant $c^2/G = 1.35\times10^{27} kgm^{-1}$ is very big.

In astronomy, Solar mass: Solar radius is $M/R = 2.848\times10^{21} kgm^{-1}$. For the solar system R is bigger, M/R is smaller. For black hole, $r = 2Gm/c^2$, so 1>0.5 hold always. For Galactic System $M/R \approx 4\times10^{42} kg / 2.85\times10^{21} m = 1.4\times10^{21} kgm^{-1}$.

The known total mass of Universe is $M = 2\times10^{53} kg$, and corresponding scale is $R = 4.2Gpc = 1.3\times10^{26} m$ [20], so $M/R = 1.538\times10^{27} kgm^{-1}$. Both are comparable, and M/R is slightly big. It corresponds just to the acceleration of the universe and dark energy [21].

3. Basic Calculations of Negative Matter as Unified Dark Matter-Energy

Based on this model, we may calculate simply some results.

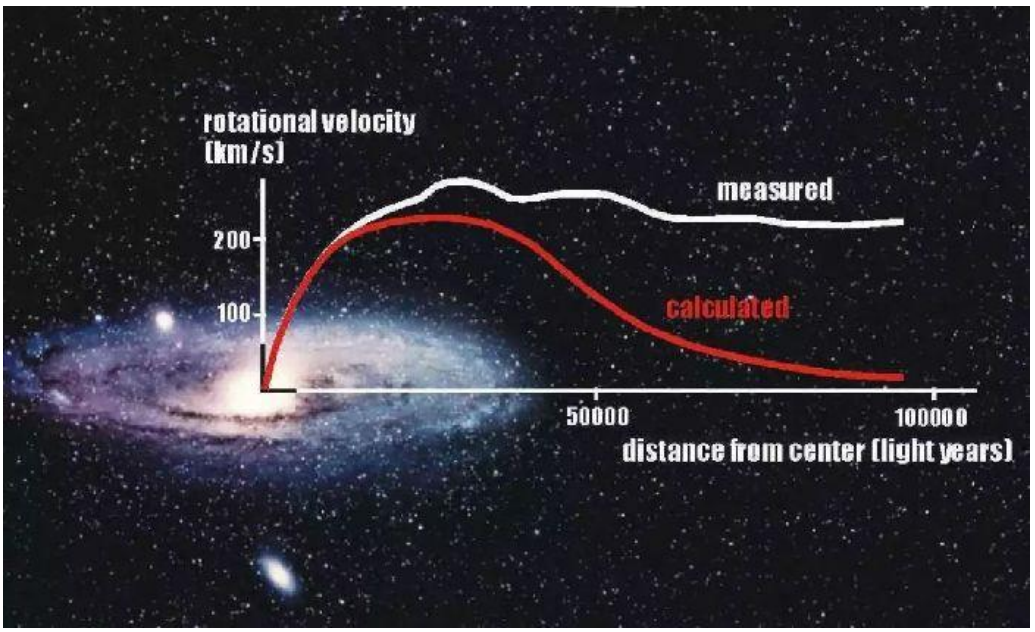

Fig. 1: In Andromeda Galaxy the curve of the rotational velocity with distance. The red curve is the theoretical calculated prediction of the no-dark matter, and the white curve is the measured curve. Figurate source: https://phys.org/news/2011-12-dark.html

In Fig.1 the difference between the two curves is one of the key evidence for the existence of dark matter. According to classical mechanics the rotational velocity is:

$$\frac{1}{R}V^2 = \frac{GM}{R^2}. \qquad (3)$$

The measured curve for large scale R> R_0 is:

$$V^2 = \frac{GM}{R} \approx \text{constant}. \qquad (4)$$

If the negative matter is introduced $M \to M_+ - M_-$, the equation (3) will become:

$$\frac{G}{R^2}(M_+ - M_-) = \frac{1}{R}V^2. \qquad (5)$$

The total mass of the spherality galaxy inside radius R is:

$$M(R) = M_+ - M_- = \int_0^R (\rho_+ - \rho_-)dV = (\rho_+ - \rho_-)\int_0^R 4\pi r^2 dr = \frac{4\pi}{3}R^3(\rho_+ - \rho_-). \quad (6)$$

$$\frac{dV}{dt} = -\frac{G}{R^2}(M_+ - M_-) = -\frac{4\pi}{3}GR(\rho_+ - \rho_-). \qquad (7)$$

For the plane disk-like galaxy

$$M(R) = (\rho_+ - \rho_-)\int_0^R 2\pi r dr = \pi R^2(\rho_+ - \rho_-). \qquad (8)$$

$$\frac{dV}{dt} = -\pi G(\rho_+ - \rho_-). \qquad (9)$$

If $\rho_+ \approx \rho_-$ and $M_+ \approx M_-$, dV/dt$\approx$0, integral derive V and V^2 are approximate constants (Fig.1) , the expansion rate is unchanged. When $\rho_+ - \rho_-$ >0, $M_+ - M_-$ >0, dV/dt<0, the expansion rate is deceleration. If $\rho_+ - \rho_-$ <0, $M_+ - M_-$ <0, dV/dt>0, the expansion rate is acceleration.

Astronomy on the negative matter includes both the negative matter each other and between the positive-negative matters. We discussed corresponding black hole and relative problems, in particular, the grand unified theory (GUT). The negative matter is the simplest dark matter, and a huge repulsive force between the positive matter and negative matter shows dark energy, and creates inflation cosmos. Further, we researched various theories of the negative matter and the cosmology of the negative matter. Based on the cosmic hydrodynamics and 2+1 dimensional plane general relativity we applied the qualitative analysis theory to discuss mathematically the cosmic evolution, which may form many worlds or single world, and may obtain some possible conditions on many worlds [22].

We searched some results and tests of the negative matter as dark matter, in which a judgment test is an opposite repulsive lensing, but usual cases are gravitational lensing for huge massive matter. We supposed that dark matter-energy is completely the negative matter, then may calculated a ratio

between negative mass and baryon mass, which agree with new observed value. We discussed advantage the negative matter as dark energy, for example, unified mass and energy in relativity, determined space-time scales on inflation, and phantom must be a type of the negative matter, and it is similar with weakly interacting massive particles (WIMPs), etc [23].

In the modern cosmology [18,19] the usual total energy of radiation-dominated universe is energy of photon M_+c^2. The total energy of positive and negative matters is $M_+c^2 - M_-c^2$. Because inflation is origin of nothing, the total energy should be zero, i.e., $M_+ = M_-$.

When the evolutional process from radiation-dominated universe to the matter-dominated universe, the known total energy of usual baryon matter of non-relativity is:

$$M_+c^2 - \frac{GM_+^2}{R_+}. \qquad (10)$$

Assume that dark matter is completely the negative matter, so we may calculate an evolutional ratio between total matter and usual matter from 1 to present 11.82 or 7.88 [15,16]. According to new data [5,6], ratio between usual matter, total matter and dark energy is 4.84:30.8:69.2, so 30.8/4.84=6.36, and 69.2/4.84=14.3.

Such the total energy is [15,16]:

$$E_t = M_+c^2 - \frac{GM_+^2}{R_+} + (-M_-c^2 - \frac{GM_-^2}{R_-}) + \frac{GM_+M_-}{R_\pm}. \quad (11)$$

We supposed that for early inflation cosmology the positive matter and the negative matter have the same mass $M_+ = M_- = M$, which are separated, and $R_+ = R_- = R$. So Eq.(10) becomes to:

$$E_t = -\frac{2GM^2}{R} + \frac{GM^2}{R_\pm}. \qquad (12)$$

Corresponding force is:

$$F = -\frac{GM^2}{R_\pm^2 R^2}(2R_\pm^2 - R^2) = -\frac{GM^2}{R_\pm^2 R^2}(\sqrt{2}R_\pm + R)(\sqrt{2}R_\pm - R). \quad (13)$$

If R< $\sqrt{2}R_\pm$, it is gravitation; if R> $\sqrt{2}R_\pm$, it is repulsion. R= $\sqrt{2}R_\pm$ is the inflection point for the accelerated expansion of the universe.

First, it is qualitatively consistent. The positive and negative matters in the early universe were dominated by gravitation, respectively. Later the velocities slow down, the repulsion appears at the inflection point, but it is not in the exponential form.

Next, in Cosmology the distance R is proportional to time T=R/v, which corresponds to the light cone $ds^2 = dr^2 - c^2dt^2 = 0$， R=cT. So R= $\sqrt{2}R_\pm$ corresponds to $T = \sqrt{2}T_0$. If T=13.8 billion years is the

current cosmic time, so an inflection point appeared at $T_0 = T/\sqrt{2} = 13.8/\sqrt{2}$ =9.760 billion years. This is the same with accelerated expansion at 9.7 billion years.

Of course, the actual situations are more complicated. But, this is a model that can be computed and compared, and may also be developed.

4. Negative Matter in Cosmology, and Inflation

It is kwon that the gravitational field equations with the cosmological constant are:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + \Lambda g_{\mu\nu} = 8\pi k T_{\mu\nu} . \qquad (14)$$

We proposed the field equations of general relativity on the negative matter [10-16,22,23]:

$$G_{\mu\nu} = 8\pi k (T_{\mu\nu} - T'_{\mu\nu}) . \qquad (15)$$

So the cosmological constant Λ corresponds to the negative matter, i.e., $\Lambda = 8\pi k T'_{\mu\nu} / g_{\mu\nu}$. Here $\Lambda g_{\mu\nu}$ corresponds to the negative energy state and vacuum energy (Dirac sea), and is consistent with conformal gravity theory.

Caldwell [24] proposed phantom as cosmological consequences of a dark energy component with super-negative equation of state, whose cosmic energy density has negative pressure. The total energy is negative, so it is namely a type of negative matter. Then phantom becomes an important dark energy model.

In cosmology it is an important progress that Guth proposed inflation whose time origin is from 10^{-32} s, and cosmic scale factor exponential expansion $a(t) \approx e^{Ht}$. Then Linde and Albrecht, et al., proposed the chaotic inflation. We proposed the mechanism of inflation as origin of positive-negative matters created from nothing at the same time, whose quantum fluctuations correspond just to the chaotic inflation [10-16,22,23]. It is a Planck time 10^{-43} s, and length 10^{-33} cm. At this very small space the positive matter and negative matter are the very strong repulsive interaction, and the exponential inflation is just a form of the strong interaction

$$F = -g^2 \frac{e^{-kr}}{r^2}, \qquad (16)$$

in which the positive matter is g, and the negative matter is –g, so F>0 is a huge strong repulsive force for the length inside 10^{-13} cm. When the scale is bigger than one of the strong interaction, the inflation finishes, and the positive matter and opposite matter will form two regions of topological separation repulsed each other.

5. Some Possible Ways on Observe Dark Matter in the Milky Way

In 2007, COSMOS obtained first three-dimensional distribution map of dark matter on world [25]. We researched the most complete theory of the negative matter, and its quantum theory, and corresponding Lobachevskian geometry. We proposed a judgment test for the negative matter as dark matter, and other possible tests [12-16,22,23].

Various positive matter and black hole exhibit the gravitational lensing effect. The negative matter will be the repulsive lensing, and even will form the bigger Einstein ring in some black regions. Both should be different in observations.

Recently, Reid and Zheng [26] researched to show that the Milky Way structure is a barred spiral galaxy with four spiral arms (Fig.2).

Fig. 2: The Milky Way structure

There must have dark matter in the Milky Way. We should closely observe the dark regions of the Milky Way (Fig.2), which could be three categories: gas cloud, black hole, or dark matter. The black holes form some spherical regions, while gas cloud and dark matter may not be completely regular. When the Earth is in different positions of the solar system throughout a year, the background stars of these regions will be respectively constant, gravitational lensing, or opposite repulsive lensing if negative matter as dark matter. The both angles of deflection are:

$$\Delta\varphi = \pm\frac{4GM}{c^2R}, \qquad (17)$$

in which R is the same for a black hole, while R for negative matter is not necessarily the same. Many observatories should be able to observe these differences [27,28]. Further, we predict that the place where negative dark matter exists most likely between visible spiral arms, and the closer to the edge, the more likely. It is consistent with about one-third of the matter in the solar neighborhood must be dark matter. This produces the stability of the spiral arms, and approximate stable state in Milky Way. We look forward to the early results of the astronomers.

Panek described some possible observe ways on dark matter and dark energy [29]. Siegel in *Beyond the Galaxy* collected some pictures of astronomical observations on dark matter [30]. Recently, astronomers observed a super-huge hole about 2 billion light-years scale (Fig.3). This is most likely an invisible region of the negative matter, because its form is irregular, and cannot be origin of black hole with spherical symmetry.

Fig. 3: A super-huge hole in Universe

Fig.3 as a negative matter should be able to see the image of the repulsion lensing.

6. Possible Mechanism on Few Opposite Matter, and Origin of Mass Conclusion

The origin of Universe is always an attracting science questions [31-33]. In the modern cosmology [18,19] we think that two evolutional processes are very important, in which inflation produces the positive-negative matters and mass, and the matter-dominated universe in the visible region produces the opposite matters and charges. Both introduce the gravitational constant G, and the fine-structure constant α, respectively. While the negative matter region is invisible and hard to know.

This is known that the big bang and black hole contracts to singularities are two opposite processes at different scales. When the energy decreases, the inversion process of neutron star formation corresponds to the generation of charges in the universe. It is the evolutional process from radiation-dominated universe to the matter-dominated universe, the universe first forms neutrons, and then the neutron decay $n \to pe^{-}\overline{\nu}_e$, and produces simultaneously different charges, and derive three basic fermions proton p, electron e, and neutrino, which correspond to three elements of strong, electromagnetic, and weak interactions [34]. So far the high energy experiments in the past sixty years

have shown that the smallest mass fermions are proton, electron, neutrino and photon, which form the simplest model of particles. These fermions seem to be inseparable truth elements, because further experiments derive particles with bigger mass. They correspond to four interactions, and are also only stable particles. The final simplest theory is based on leptons (e-ν_e) and nucleons (p-n) or (u-d) in quark model with SU(2) symmetry and corresponding Yang-Mills field. Other particles and quark-lepton are their excited states [34].

Further, we propose a possible mechanism of missing antimatter when the attraction of the positive and negative charge is greater than the repulsion of positive and negative masses. We extend the total energy to the case with electromagnetic interactions. Only the simplest electrostatic forces are considered, assume that e is negative charge and Q is positive charge：

$$E_t = (M_+c^2 - \frac{GM_+^2}{R_+} + \frac{e_+Q_+}{R_+}) + (-M_-c^2 - \frac{GM_-^2}{R_-} + \frac{e_-Q_-}{R_-}) + (\frac{GM_+M_-}{R_\pm} + \frac{e_+e_- - Q_+e_- - e_+Q_- + Q_+Q_-}{R_\pm}). \quad (18)$$

Specifically, it is known that the present existence is the proton p and electron e, which constitute hydrogen. Their antimatters are the negative proton p and positron e. Assume that the presence of proton p and electron e in the negative matter. A mass m in antimatter has charge q, and a mass –M in the negative matter has opposite charge –Q. As long as the attraction qQ of the positive and negative charge is greater than the repulsion of positive and negative masses, i.e., qQ>GmM, such the opposite charged antimatter and negative matter can annihilate and decrease when fluctuations. Probably it may explain the puzzle of missing antimatter. Some new predictions can be obtained: 1. The known world is mainly positive matter. 2. Very little antimatter. 3. There are more remaining, mainly neutral antimatter and negative matter. The most basic protons and the electrons are charged particles, and the neutrons are unstable, so more remainders are neutral particles, especially neutrinos and photons, and neutrons. It accords also with Sakharov's three conditions. Further, we should consider the motion of the charged particles and the corresponding electromagnetic theory and electrodynamics, and QED. Moreover, the negative matter-energy as the Dirac sea is not occupied [8,9], and is repulsion with all positive matter, so there is not vacancy or hole, i.e., anti-particle.

From G, we derive Eq.(1). From α, the Rosen-Ross mass formula of leptons-meson is derived [35]:

$$M = m_e(1+\frac{n}{2\alpha}). \quad (19)$$

When n=3, M=206.554 m_e=105.55MeV $\approx m(\mu^\pm)$ (105.66); n=4, M=275.072 m_e=140.56MeV $\approx m(\pi^\pm)$ (139.57).

According to the string model, matter produces, and corresponding string produces. Usual string has two moving states: oscillation and rotation, so we proposed corresponding potential and the equation of the emergence string:

$$\frac{d^2\psi}{dr^2}+[-\frac{K(K+1)}{r^2}+2m(E-U)]\psi=0. \quad (20)$$

Its energy spectrum is the GMO mass formula and a modified accurate mass formula [35-37]:

$$M = M_0 + AS + B[I(I+1) - S^2/2]. \quad (21)$$

These are some relations between the string and observable experimental data.

For the $J^p = 1^+/2$ baryon octet, let M_0=910.75, A=–222.04 and B=38.43MeV, so

$$m(n) = 939.5725, m(\Lambda) = 1115.6, m(\Sigma^0) = 1192.46, m(\Xi^0) = 1314.89\,MeV. \quad (22)$$

Therefore, Eq.(21) agrees completely with the experimental data of the neutral baryons [38].

For the $J^{pc} = 0^{-+}$ meson octet, let A=0, M_0=549.4 and $B = -207.22$ MeV, so

$$m(\pi^0) = 134.96, m(K^0) = 497.6, m(\eta) = 549.4\ \text{MeV}. \quad (23)$$

The neutral mesons agree completely within the range of error [37]. (22) and (23) are all neutral hadrons, and baryon and meson can be unified by M=m. From (19) and (21) we may calculate the basic mass spectrum, which are all composed of first generation of lepton-quark (u-d and e-ν_e) extended to a part of second generation (s and μ) in particle astrophysics [20].

According to the symmetry of s-c quarks, the heavy flavor hadrons which made of u, d and c quarks may be classified by SU(3) octet and decuplet, and some simple mass formulas are obtained, then m(Ξ_{cc})=3715 or 3673MeV are predicted [37,39]. In July 2017 LHC observed a new and very charming baryon $\Xi_{cc}^{++} = ucc$, whose mass is 3621Mev. It agrees more on new formula (21), whose error only is 1.4%. Further, we predicted m(Ω_{cc}^{+})=3946, or 3950.8, or 3908.2MeV, etc. Moreover, this method may be extended to other heavy flavor hadrons, and predict $m(\Xi_{bb})$=10396.8 or 10348.9MeV, etc. It is a quantitative and testable theory.

In mass formula (21), M_0 is the basis, the string oscillation produces S and different excited states (second and third generation quarks and particles), and the string rotation produces I (corresponding charge). Let

$$M_0 = m_0 + n\Delta m\,. \quad (24)$$

Such m_0=188.05, Δm=361.35MeV, then n=1, M_0=549.4 is meson, and n=2, M_0=910.75 is baryon, $\Delta m : m_0$=2:1.

7. Conclusion

It is a notable process that the positive energy from a conjecture became to a theorem, and then to a restriction for the negative matter. But, the premises on proof of the positive energy conjecture cannot rule out Dirac's genius prophecy on the negative energy state. Further, a completely similar approach can prove that the negative matter region is always the total negative energy, and gravity is also negative energy, so the total negative energy is greater [16].

Usually, the positive matter and the negative matter are two regions separated each other, and both are all stable. When they annihilate, both are certainly unstable.

Generally, the whole matter space is divided into:

I. Positive matter region, the gravitational energy is negative, and the total energy is positive.

II. The negative matter region, the gravitational energy is negative, and the total energy is greater negative energy.

III. A region between positive and negative matters, the repulsion energy is positive.

The total region of the three is mixed, the positive matter and negative matter are equal, the double gravity is greater than the repulsion, the total energy is negative, so that the whole universe accelerates the expansion, and corresponds to the dark energy as a huge repulsive force.

In fact, some physicists researched already the negative energy and various related problems. Early in 1898 Arthur Schuster conjectured the existence of new sun with the negative mass [40].

Recently, various theories of unified dark matter and dark energy become a new trend, which is consistent with Occam's Razor. Bertacca, et al., analyzed and reviewed cosmological models in which the dynamics of a single scalar field accounts for a unified description of the Dark Matter and Dark Energy sectors, dubbed Unified Dark Matter (UDM) models [41]. De-Santiago and Cervantes-Cota generalized a unification model for dark energy, dark matter, and inflation with a single scalar field with noncanonical kinetic term [42]. Xue-Mei Deng studied a modified generalized Chaplygin gas as the unified dark matter and dark energy revisited [43]. Liao, et al., discussed an observational constraints on unified dark matter including Hubble parameter data [44].

In 2018 Farnes proposed a unifying theory of dark energy and dark matter: Negative masses and matter creation within a modified ΛCDM framework [45]. Further, Chung modified the Farnes' unifying theory of dark energy and dark matter, and researched baryonic matter in the positive-negative mass universe pair, and Protogalaxy and galaxy evolutions [46]. Davari, et al., investigated a new

phenomenological parameterization for unified dark matter and dark energy [47]. Gurzadyan, et al., discussed two fundamental constants of gravity unifying dark matter and dark energy [48]. Perković, et al., proposed the dark sector unifications as dark matter-phantom energy, dark matter-constant w dark energy, and dark matter-dark energy-dark matter [49]. Brandenberger, et al., searched unified dark matter, dark energy and baryogenesis via a "cosmological wetting transition" [50]. Benisty, et al., studied unification of dark energy and dark matter from diffusive cosmology [51]. Benisty researched unified dark energy and dark matter from dynamical spacetime cosmology [52].

Moreover, in 1929 a physicist Ivar Waller of Sweden has proposed that the negative energy is an integral part of quantum theory.

In a word, the negative matter as a candidate of unified dark matter and dark energy is not only the simplest, and is calculable, observable and testable, and may be changed and developed.

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