Basis on Negative Matter as Unified Dark Matter and Dark Energy

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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. 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. 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. The negative matter as a candidate of dark matter and dark energy is not only the simplest, and is calculable and testable.

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

1. Introduction

Now dark matter and dark energy are always basic focus in astronomy, and total physics. They are also the greatest mysteries in 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].

Recently, in Nature there are two reports: "Tighter limits on dark matter" and "Dark-matter evidence weakens". Both are based on search for ultralight scalar dark matter with atomic spectroscopy [3], and 7.1 keV sterile neutrino constraints from X-ray observations of 33 clusters of galaxies with Chandra ACIS [4]. Vermeulen, et al., discussed direct limits for scalar field dark matter from a gravitational-wave detector [5]. Caldwell, et al., discussed observations continue to indicate that the Universe is dominated by invisible dark matter and dark energy [6].

For new data [7,8], 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.

Some believe that dark energy distributes uniformly in the whole space, and its interactions are repulsive. But, in the solar system dark energy and dark energy cannot exist, since in which general relativity is very exact. 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 [9].

In this paper, we propose three basic principles of the negative matter as a candidate unified dark matter and dark energy, and derive a conclusion and corresponding calculate results.

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

In 1928 Dirac predicted anti-particles and the negative energy state from his equation, and he emphasized: "we cannot ignore the negative energy states" [10]. 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> [11]. 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 [12-16], 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:

$$F = -\frac{G}{r^2}M_1M_2, \tag{1}$$

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 (Fig.1) [12,13].
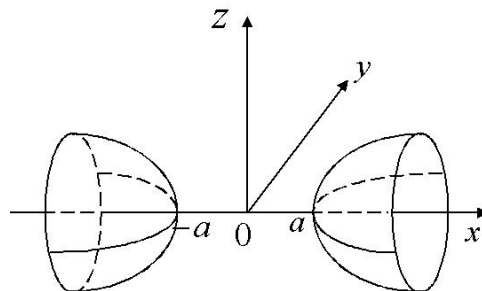

Fig. 1. Positive and negative matters as two topological separation regions

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 [12-16]. 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 [12,13]. 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 [16].

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

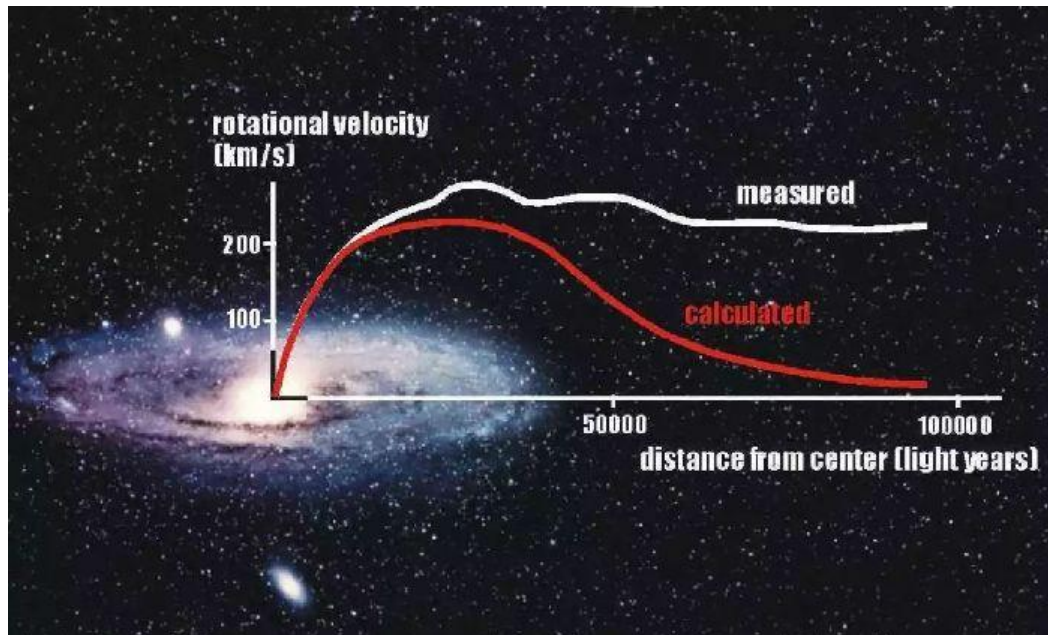Based on this model, we may calculate simply some results.

Fig.2 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.2 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:

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

The measured curve for large scale $R > R_0$ is:

$$V^2 = \frac{GM}{R} \approx \text{constant}.$$ (3)

If the negative matter is introduced $M \rightarrow M_+ - M_-$, the equation (2) will become:

$$\frac{G}{R^2}(M_+ - M_-) = \frac{1}{R}V^2.$$ (4)

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

$$M(R) = M_+ - M_- = \int_0^R (\rho_+ - \rho_-)dV = (\rho_+ - \rho_-)\int_0^R 4\pi r^2 dr = \frac{4\pi}{3}R^3(\rho_+ - \rho_-).$$ (5)

$$\frac{dV}{dt} = -\frac{G}{R^2}(M_+ - M_-) = -\frac{4\pi}{3}GR(\rho_+ - \rho_-).$$ (6)

For the plane disk-like galaxy

$$M(R) = (\rho_+ - \rho_-)\int_0^R 2\pi r dr = \pi R^2(\rho_+ - \rho_-).$$ (7)

$$\frac{dV}{dt} = -\pi G(\rho_+ - \rho_-).$$ (8)

If $\rho_+ \approx \rho_-$ and $M_+ \approx M_-$, dV/dt ≈ 0, integral derive V and V^2 are approximate constants (Fig.2).

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:

$$M_+c^2 - \frac{GM_+^2}{R_+}. \tag{9}$$

Assume that dark matter and dark energy are completely the negative matter, so the total energy includes three parts: one of the positive matter, one of negative matter, and their repulsion force:

$$E_t = M_+c^2 - \frac{GM_+^2}{R_+} + (-M_-c^2 - \frac{GM_-^2}{R_-}) + \frac{GM_+M_-}{R_\pm}. \tag{10}$$

Both ratio is:

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

Since the gravitation is negative energy, so the ratio will increase along time and scale R. This will show that the expanding universe leads to increasing numbers of the negative energy-dark energy.

We suppose that for early inflation cosmology the positive matter and the negative matter have the same mass $M_+ = M_- = M$, and both are separated. In order to simplify assume that positive and negative matters form two identical spheres, respectively, so $R_+ = R_- = R, R_\pm = 2R$. Such Eq.(11) is simplified to:

$$\frac{-\frac{3GM^2}{2R}}{Mc^2 - \frac{GM^2}{R}} = \frac{3}{2}\frac{GM}{GM - Rc^2}. \tag{12}$$

It is known that the total mass of Universe is $M = 2 \times 10^{53} kg$, and corresponding scale is $R = 4.2 Gpc = 1.3 \times 10^{26} m$ [20], so

$$Rc^2 = 1.17 \times 10^{43} m^3 s^{-2}, \text{ and } GM = 1.34 \times 10^{43} m^3 s^{-2}. \tag{13}$$

A simple calculation obtains $\frac{3}{2}\frac{GM}{GM - Rc^2} = 11.82$. Of course, the actual situations are more complicated. But, this is a model that can be computed and compared, and may also be developed.

According to new data, ratio between usual matter, total matter and dark energy is

4.84:30.8:69.2 [7,8], so 30.8/4.84=6.36, and 69.2/4.84=14.3.

If $R_\pm = R$, positive matter and negative matter are mix together in the same volume, so Eq.(11) is simplified to:

$$\frac{-\dfrac{GM^2}{R}}{Mc^2 - \dfrac{GM^2}{R}} = \frac{GM}{GM - Rc^2} = 7.88. \tag{14}$$

Since G, M, c are invariance, R is bigger, this ratio is bigger. Further, when $M_+ - M_- < 0$, dV/dt>0, the expansion rate is acceleration.

4.Negative Matter in Cosmology, and Inflation

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

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + \Lambda g_{\mu\nu} = 8\pi k T_{\mu\nu} . \tag{15}$$

We proposed the field equations of general relativity on the negative matter [12-16]:

$$G_{\mu\nu} = 8\pi k (T_{\mu\nu} - T'_{\mu\nu}) . \tag{16}$$

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 [21] 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 [12-16]. 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

$$F = -g^2 \frac{e^{-kr}}{r^2},$$ (17)

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.

In 2007, COSMOS obtained first three-dimensional distribution map of dark matter on world [22]. 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 [14-16].

Various positive matter and black hole exhibit the gravitational lensing effect. The negative matter will be the repulsive lensing (Fig.3), and will form the bigger Einstein ring. Both should be different in observations.
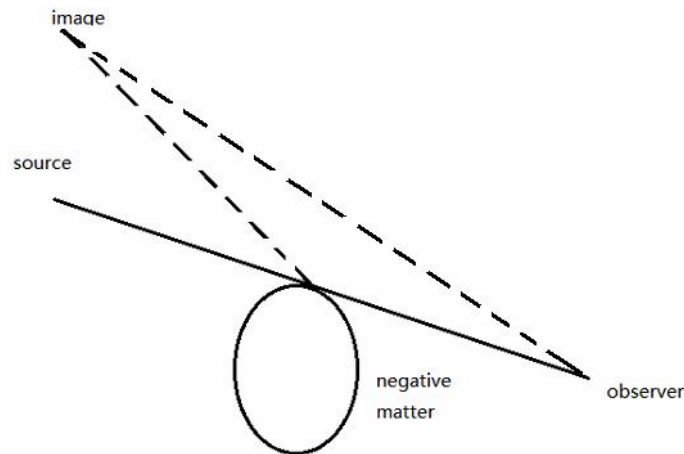

Fig.3. Repulsive lensing

Recently, astronomers observed a super-huge hole about 2 billion light-years scale (Fig.4). 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.4 A super-huge hole in Universe

5. 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.

Usually, the positive matter and the negative matter are two regions separated each other (Fig 1), and both are all stable. When they annihilate, both are certainly unstable.

Generally, the whole matter space is divided into:

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

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

3. 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 should be negative, so that the

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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 [23]. The positive, opposite, and negative, negative-opposite matters may form just the most perfect symmetrical world [14-15].

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

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