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Rewriting General Relativity Based on Dark Energy

Wook Koh

Dept. of Digital Media, Ajou University
Suwon, South Korea

Soonhoi Ha

Dept. of CS, Seoul National University
Seoul, South Korea

Abstract

There are strong indications the general relativity theory is incomplete [1]. Observational data that is taken as evidence for dark energy and dark matter could indicate the need for new physics [5]. In this paper, general relativity is rewritten based on the X-particles of dark energy. The goal is to help classical mechanics and general relativity to reconcile with the laws of quantum physics [2][3][4].

Keywords: dark energy, X-particle, X-theory, general relativity

1 Introduction

General relativity has emerged as a highly successful model of gravitation and cosmology, which has so far passed many unambiguous observational and experimental tests. However, there are strong indications that the theory is incomplete [1] and needs rewriting [6]. The problem of quantum gravity and the question of the reality of spacetime singularities remain open. Observational data that is taken as evidence for dark energy and dark matter could indicate the need for new physics [5]. Dark energy is an unknown form of energy that is hypothesized to permeate all of space, tending to accelerate the expansion of universe [7][9][12][24][26].

In this paper, general relativity is rewritten based on the X-particles of dark energy. As an origin of dark energy, an X-particle with repulsive force proportional to energy density has been proposed [2]. An X-particle is postulated to have only relativistic mass (zero rest mass), and act like a particle that has a definite position and momentum. In this model, the main cause of anomalies in quantum mechanics is postulated to be dark energy. Thus many parts of classical mechanics would be valid if we add dark energy, spacetime, and Lorentz transformation in the model [3]. The theory postulates that an X-particle has a mechanism to form the gravitational field and to convert it to a gravitational force. And the X-particle passes the gravity signals to its neighboring X-particles at the speed of light to form the ubiquitous gravitational field. Since all particles in the universe exist within the sea of X-particles, each particle's position and momentum are affected by the interaction with X-particles around them [3].

The theory's goal is to help classical mechanics and general relativity to reconcile with the laws of quantum physics. In the previous works on X-particle theory, it was shown how X-particles can create the wave appearance of a particle. The Schrödinger's equation is a practical way of dealing with the probabilistic nature of X-particles which guides the quantum-scale particle. The uncertainty principle were explained due to the interaction with X-particles which form the gravitational field [3], and the paradoxes of double-slit experiment and the quantum entanglement were interpreted by X-particles [4].

The rest of the paper is arranged as follows. In section 2, the previous works on the X-particle are presented. In section 3, we rewrite the general theory of relativity to incorporate the X-particles of dark energy. Finally, we end with some remarks and future research topics in the last section.

2 Previous Work

2.1 X-particle

The X-particle theory postulates that dark energy exists in the form of X-particle and permeates all of space [2]. Like photon, the particle is a boson that has only relativistic mass (zero rest mass) and acts like a particle with a definite position and momentum.

Suppose there are X-particles i, j with distance l_{ij}. If we squash them, there is a large repulsive force that pushes them apart. On the other hand, if we pull them apart, there is an attractive force field. When the attractive force is equal to the repulsive force ($F_a = F_r$), we define l_{ijo} as the "stable distance". At the same time, m_{io} and m_{jo} are defined as the "stable " for X-particle i, j. Throughout the universe, each X-particle exerts force to one another (negative pressure) to reach its stable distance l_{ijo}. We postulate the repulsive force to be proportional to energy density

$$F_r = G_r \frac{m_i + m_j}{{l_{ij}}^3}, \tag{2.1}$$

where G_r is a repulsive variable, and l_{ij} is the distance between particle i, j. The gravitational attractive force between particles i, j with G as the gravitational constant is

$$F_a = G \frac{m_i m_j}{{l_{ij}}^2}. \tag{2.2}$$

The relation between the repulsive variable G_r and the gravitational constant G is

$$G_r = G \frac{m_i m_j}{m_i + m_j} l_{ijo}. \tag{2.3}$$

Therefore the "net" repulsive force F exerted on the particle can be defined as

$$F = F_r - F_a = G \frac{m_i m_j}{{l_{ij}}^2} (\frac{l_{ijo}}{l_{ij}} - 1). \tag{2.4}$$

As l_{ij} decreases (less than l_{ijo}), there is a large repulsive force F that pushes particles apart. On the other hand, as l_{ij} increases (larger than l_{ijo}), an attractive force F dominates. As l_{ij} increases to infinity, F approaches to zero. When l is equal to the stable distance l_{ijo}, particles i, j will experience zero force. We can observe an analogical example in electromagnetic forces between atoms, where at the radius of an atom, two atoms may experience nearly zero force.

When particles have a same mass, we can simplify variables as

$$m = m_i = m_j, \qquad l = l_{ij}, \qquad m_o = m_{io} = m_{jo}, \qquad l_o = l_{ijo}. \tag{2.5}$$

And the net repulsive force equation becomes

$$F = G(\frac{m}{l})^2(\frac{l_o}{l} - 1). \tag{2.6}$$

We postulate that the angular frequency of X-particle as ω_x that satisfies

$$E = mc^2 = \hbar\omega_x, \tag{2.7}$$

and

$$c = l\omega_x. \tag{2.8}$$

From Eq.(2.7) and Eq.(2.8), we can obtain the key equation of X-particle that shows the relation between m and l

$$mlc = \hbar. \tag{2.9}$$

It is important to note that, assuming $\hbar$ and c are constants, the product of m and l (ml) is constant. We can get l as a function of m from Eq. (3.15) and vice versa

$$l = \frac{\hbar}{mc}. \tag{2.10}$$

The X-particle model was originally developed to explain the accelerated expansion of the universe [2]. And the theory has been expanded to accommodate the following X-gravitational field model [3].

2.2 X-Gravitational Field

In a field model, rather than two particles attracting each other, the particles distort space-time via their mass, and this distortion is what is perceived and measured as a "force". In such a model one states that matter moves in certain ways in response to the curvature of spacetime [22].

In X-gravitational field model, a gravitational field can be formed with the X-particle distribution [3], and Newtonian's gravitational equation is postulated to be valid if we add dark energy and Lorentz transformation into the model. In order to simplify the problem, one dimensional array of X-particles is considered as an approximated model.

Suppose X-particles from $X_1..X_\infty$ lined up from left to right with mass M ($M \gg m_i$) at the leftmost. For each X_i there is a gravitational attractive force $F_a[i]$ between M and X_i

$$F_a[i] = G\frac{Mm_i}{{R_i}^2}, \tag{2.11}$$

where m_i is the mass of X_i, and R_i is the distance between M and X_i. As X_i is attracted to M, Newton's third law of "action equals reaction" is applied between X_i and X_{i-1}. Here X_i exerts a force $F_a[i]$ on the X_{i-1}, and the X_{i-1} will push back on X_i with an equal repulsive force $F_r[i-1,i]$ in the opposite direction

$$F_r[i-1,i] = G\frac{m_i m_{i-1}}{{l_{i,i-1}}^2}(\frac{l_o}{l_{i,i-1}} - 1), \tag{2.12}$$

where $l_{i,i-1}$ is the distance between X_i and X_{i-1}. For i from 2 to ∞, if we apply Newton's third law of action equals reaction, we get

$$F_a[i] = F_r[i-1,i]. \tag{2.13}$$

The model can be applied to a three dimensional space with multiple mass objects under the law of superposition. For any X-particle X_i, there are gravitational attractive forces and repulsive forces exerted by neighboring X-particles and other masses. Based on Newton's third law, the attractive forces and repulsive forces of X-particles balance each other by adjusting the distance l with neighboring particles. Therefore it creates quantized distribution of X-particles and spaces between them by forces of gravitational attraction and repulsion.

In that process, each X-particle i has the gravitational force field $g[i]$ information at the current position. From Eq.(2.11) we can get

$$g[i] = \frac{F_a[i]}{m_i} = G\frac{M}{{R_i}^2}. \tag{2.14}$$

We postulate that an X-particle has a mechanism to form the gravitational field and to convert it to a gravitational force. And the X-particle passes the gravity signals to its neighboring X-particles at the speed of light to form the ubiquitous gravitational field throughout the universe. For instance, if we place a mass $\hat{M}$ at the position of X-particle i, the force exerted by the gravitational force field i to the mass $\hat{M}$ is

$$F_{\hat{M}} = F_g[i] = \hat{M}g[i] = G\frac{M\hat{M}}{{R_i}^2}. \tag{2.15}$$

The signal that reflects the change of $\hat{M}$ will reflect the spacetime concept and reach mass M after some time delay

$$t_i = \frac{R_i}{c}. \tag{2.16}$$

Therefore X-gravitational field is formed from the dark energy distribution of X-particles, where the quantized gravitational field can be obtained from Eq.(2.14).

2.3 Inertial Frame of Reference

An inertial frame of reference is a frame of reference that describes time and space homogeneously, isotropically, and in a time-independent manner [14]. All inertial frames are in a state of constant, rectilinear motion with respect to one another. Measurements in one inertial frame can be converted to measurements in another by the Galilean transformation in Newtonian physics and the Lorentz transformation in special relativity [16].

As an X-particle X_i gets closer to the particle M, the gravitational attractive force gets stronger by the increase of m_i as well as the decrease of R_i. Therefore the particle forms very close ties with X-particles in close proximity. In general relativity, in any region small enough for the curvature of spacetime and tidal forces to be negligible, one can find a set of inertial frames that approximately describe that region [17]. In a gravity field created by X-particles, a "hierarchical" inertial frame of reference is formed by X-particles that are tightly connected by the attractive forces. The boundary of hierarchical inertial frame of reference is fuzzy, dynamic, and relative to the other forces. The hierarchy can range from sub-atomic particles (leaf) to the earth, to the galaxy, and to the entire universe (root). Eq.2.11 shows that, as the magnitude of M increase, the attractive forces of X-particles increase, and the inertial frame of reference becomes larger and more stable. Therefore the "stability" of inertial frame of reference strongly depends on the mass M and the distance R_i.

Einstein's comment on the equivalence principle shows the limit in explaining the universe with dark energy. He assumed the "complete" physical equivalence of a gravitational field and a corresponding acceleration of the reference system. That is, being on the surface of the Earth is equivalent to being inside a spaceship (far from any sources of gravity) which is being accelerated by its engines [25]. Even though Einstein's equivalence principle is a good approximation of nature, it may not work for certain domains in physics, when the effects of X-particles are involved. First, we need to note that there is a huge gap between the mass of the Earth and that of the spaceship. The gravitational field and the inertial frame of reference have to be different to each other at the quantum scale. Second, he assumed a spaceship far from any sources of gravity, which is not plausible in reality. The universe is under the influence of the ubiquitous X-particle gravitational field.

Therefore Einstein's assumption on physical equivalence of a gravitational field and a corresponding acceleration of the reference system is incomplete. It may provide an interesting research topic for certain scientists who think that the best evidence for quintessence would come from violations of Einstein's equivalence principle [18].

3 X-Theory

In this section, general relativity is rewritten as "X-theory" based on the X-particles of dark energy. The goal is to help classical mechanics and general relativity to reconcile with the laws of quantum physics to produce a complete and self-consistent theory of quantum gravity [2][3][4].

Some predictions of general relativity differ significantly from those of classical physics, especially concerning the passage of time, the geometry of space, the motion of bodies in free fall, and the propagation of light. Examples of such differences include gravitational time dilation, gravitational lensing, the gravitational redshift of light, and the gravitational time delay [5]. However, there are strong indications the general relativity theory is incomplete [1]. The problem of quantum gravity and the question of the reality of spacetime singularities remain open. Observational data that is taken as evidence for dark energy and dark matter could indicate the need for new physics [5].

3.1 Vacuum

Vacuum is defined as "space void of matter". However, in quantum mechanics and quantum field theory, the vacuum is defined as the state with the lowest possible energy, which is the ground state of the Hilbert space. QED vacuum contains vacuum fluctuations and a finite vacuum energy, which are an essential and ubiquitous part of quantum field theory [10]. Vacuum energy is an underlying background energy that exists in space throughout the entire universe. Their behavior is codified in Heisenberg's energy-time uncertainty principle. Still, the exact effect of such fleeting bits of energy is difficult to quantify [11].

Einstein's theory of general relativity predicts that this energy will have a gravitational effect. Most theories of particle physics predict vacuum fluctuations that would give the vacuum this sort of energy [8]. In this context, X-theory proposes a model of the vacuum as an infinite sea of X-particles of dark energy, called the X-sea. The X-particle accelerates the expansion of universe [2], sets the maximum speed (c) of any matter, and creates the ubiquitous gravitational field and the hierarchical inertial frames of reference [3]. It is the cause of the uncertainty principle, the wave-particle duality, and paradoxes such as the double-slit experiment and the quantum entanglement [4].

3.2 Lorentz transformations

Einstein, following a suggestion originally made by Poincaré, proposed that all the physical laws should be of such a kind that they remain unchanged under a Lorentz transformation [20], but did not explain why. In X-theory, X-particles set the maximum speed (c) of any object or particle in the universe [3]. As the particle's speed approaches to c, the distance with the neighboring X-particles decreases to $l_{ij} = 0$. This results in a nearly infinite amount of repulsive force to be exerted on the particle as predicted in Eq.(2.4), thereby setting the speed limit.

As Einstein did, we can derive the Lorentz transformation by arguing that there are two non-zero coupling constants λ and μ [16] such that

$$x' - ct' = \lambda\,(x - ct) \tag{3.1}$$

$$x' + ct' = \mu\,(x + ct) \tag{3.2}$$

that correspond to light traveling along the positive and negative x-axis, respectively. If we define

$$\gamma = (\lambda + \mu)\,/2 \tag{3.3}$$

$$b = (\lambda - \mu)\,/2, \tag{3.4}$$

we get

$$x' = \gamma x - bct \tag{3.5}$$

$$ct' = \gamma ct - bx. \tag{3.6}$$

Noting that the relative velocity is $v = bc/\gamma$ gives

$$x' = \gamma\,(x - vt) \tag{3.7}$$

$$t' = \gamma \left(t - \frac{v}{c^2} x \right) \tag{3.8}$$

The constant γ can be evaluated by demanding $c^2 t^2 x^2 = c^2 t'^2 x'^2$ [23].

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \tag{3.9}$$

Now we need to rewrite Newton's second law

$$F = d(mv)/dt, \tag{3.10}$$

where the mass of a body increases with velocity. As Einstein corrected Newton's formula, m has the value

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}} = \gamma m_0 \tag{3.11}$$

where the rest mass m_0 represents the mass of a body that is not moving and c is the speed of light. Here we postulate that the X-particle's repulsive force for the mass of a body is scaled as

$$F_r = \frac{F_{r_0}}{\sqrt{1 - v^2/c^2}} = \gamma F_{r_0} \tag{3.12}$$

When this change is made, both X-theory and general relativity use Lorentz transformation, and Newton's laws and the laws of electrodynamics will harmonize [20]. The predictions of general relativity that have been confirmed in observations and experiments are still valid in X-theory. However, the repulsive force of dark energy exerted on the moving object creates a fundamental difference in physics which will be discussed in the following subsections.

3.3 Twin paradox

In physics, the twin paradox is a thought experiment in special relativity involving identical twins, one of whom makes a journey into space in a high-speed rocket and returns home to find that the twin who remained on Earth has aged more. This result appears puzzling because each twin sees the other twin as moving, and so, according to an incorrect application of time dilation and the principle of relativity, each should paradoxically find the other to have aged more slowly. However, this scenario can be resolved within the standard framework of special relativity. The travelling twin's trajectory involves two different inertial frames, one for the outbound journey and one for the inbound journey, and so there is no symmetry between the spacetime paths of the two twins. Einstein argued that the twin paradox is not a paradox in the sense of a logical contradiction [15].

Even though Einstein's argument is generally right, it is incomplete. In X-theory, there is a hierarchical inertial frames of reference of the universe as described in Section 2.3. As we go down the hierarchy from the root to the leaf, the repulsive force tends to increase and the clock speed changes accordingly. As the repulsive forces of X-particles exerted on the objects are different to each other, there is no symmetry between the inertial frames. The outbound twin's clock would go slower than inbound twin's clock depending on the repulsive forces exerted on the twins by X-particles as in Eq.(3.12).

In twin paradox, it is a general belief that biological aging is not different from clock time-keeping. All processes-chemical, biological, measuring apparatus functioning, human perception involving the eye and brain, the communication of force-everything, is constrained by the speed of light. There is clock functioning at every level, dependent on light speed and the inherent delay at even the atomic level [30][15].

However, in X-theory, the equivalence is denied due to the differences in the repulsive forces of X-particles. As the exerted force on the object increases as in Eq.(3.12), even when the sum of average force is zero, the net force variation will increase, thereby violating the biological clock equivalence.

3.4 Spacetime singularity

A singularity is a point at which a given mathematical object is not defined, or a point of an exceptional set where it fails to be well-behaved in some particular way [32]. In spacetime singularity, the two most important types of spacetime singularities are curvature singularities and conical singularities. According to modern general relativity, the initial state of the universe, at the beginning of the Big Bang, was a singularity. Both general relativity and quantum mechanics break down in describing the earliest moments [19]. In X-theory, the initial state of the universe was not a singularity. We postulate that there was some form of dark energy where the net repulsive force is proportional to energy density as in Eq.(2.6). If the distance between X-particles l approaches to zero, repulsive force will increase to infinity, which will prevent the universe from being at the singularity.

Another type of singularity predicted by general relativity is inside a black hole known as curvature singularities. Any star collapsing beyond the Schwarzschild radius would form a black hole, inside which a singularity would be formed, as all the matter would flow into a certain point or a circular line, if the black hole is rotating [19][28][33]. In X-theory, no singularity is predicted inside the black hole. Matters such as X-particles cannot flow into a certain point or line, because it would require the infinite amount of repulsive forces as in Eq.(2.6). Instead, a strong X-gravitational field will be formed at the black hole that most particles and electromagnetic radiation such as light will be attracted to the small core volume. There is a certain limit that black holes can accommodate particles and objects due to repulsive forces of dark energy.

3.5 Absolute time and space

As we have noticed in the twin paradox, the physics laws are not symmetrical under Lorentz transform. Outbound twin's clock went slower than inbound twin's clock, because the exerted forces by X-particles were larger. Therefore the relative theory is not genuinely relative.

Even though Einstein's spacetime approach is right, there is no distortion of time and space in X-theory. As we mentioned in the twin paradox, biological aging is not the same as clock time-keeping. Newton said that absolute time can exist independently of any perceiver and progresses at a consistent pace throughout the universe. Absolute time is imperceptible and could only be understood mathematically. Humans are only capable of perceiving relative time, which is a measurement of perceivable objects in motion [13]. In X-theory, every object has a state of motion relative to hierarchical inertial frames of reference formed by

X-particles. The time and space in one inertial frames could be transformed to other inertial frames by Lorentz equation.

3.6 Quantum gravity

The current understanding of gravity is based on Einstein's general theory of relativity, which is formulated within the framework of classical physics. On the other hand, quantum gravity seeks to describe the force of gravity according to the principles of quantum mechanics, which is a radically different formalism [21].

The aim of quantum gravity is to describe the quantum behavior of the gravitational field. We expect the X-theory's understanding of gravity [3] would aid further work towards quantum gravity. As an origin of dark energy, an X-particle theory with repulsive force proportional to energy density has been proposed [2]. It is postulated to have only relativistic mass, and act like a particle that has a definite position and momentum. The main cause of anomalies in quantum mechanics is postulated to be dark energy. Thus many parts of classical mechanics would be valid in quantum mechanics if we add dark energy, spacetime, and Lorentz transformation into the model.

The theory postulates that an X-particle has a mechanism to form the gravitational field and to convert it to a gravitational force. And the X-particle passes the gravity signals to its neighboring X-particles at the speed of light to form the ubiquitous gravitational field. Since all particles in the universe exist within the sea of X-particles, each particle's position and momentum are affected by the interaction with X-particles around them [3]. The wave appearance of a particle is created by X-particles. The Schrödinger's equation is a practical way of dealing with the probabilistic nature of X-particles which guides the quantum-scale particle [4]. The uncertainty principle were explained due to the interaction with X-particles which form the gravitational field [3], and the paradoxes of double-slit experiment and the quantum entanglement were interpreted by X-particles [4].

The current popular approaches to the problem of quantum gravity are string theory and loop quantum gravity. At this point of time, unfortunately, it is not clear how to define the relationship between the X-theory and other quantum gravity theories [21][29]. In string theory, the fact that we can perceive only four dimensions of space can be explained by one of two mechanisms. Either the extra dimensions are compactified on a very small scale in the form of a Calabi-Yau manifold, or else our world may live on a 3-dimensional submanifold corresponding to a brane, on which all known particles besides gravity would be restricted [31][27]. On the other hand, X-theory needs four dimensions of the spacetime, 3 dimensions of the gravitational force field, and 3 dimensions of the electromagnetic field to represent the state of the space except strong and weak interactions. The gravitational field is formed by X-particles [3], and the electromagnetic field is explained by photons. Both string theory and X-theory need additional dimensions, but in the totally different context.

As an interesting research topic, it is worth noting that Planck mass

$$m_{\mathrm{P}} = \sqrt{\frac{\hbar c}{G}} \tag{3.13}$$

and Planck length

$$\ell_{\mathrm{P}} = \sqrt{\frac{\hbar G}{c^3}} \tag{3.14}$$

also satisfies the key equation of X-particle of Eq.(3.15) that shows the relation between m and l.

$$m_{\mathrm{P}}\ell_{\mathrm{P}}c = \hbar. \tag{3.15}$$

Therefore a pair of Planck mass and length is one of the possible X-particle solutions. It needs further research to know whether there is any special meaning in it.

4 Conclusion

There are strong indications the general relativity theory is incomplete [1]. In this paper, general relativity is rewritten as "X-theory" based on the X-particles of dark energy. The goal is to help classical mechanics and general relativity to reconcile with the laws of quantum physics.

X-theory proposes a model of the vacuum as an infinite sea of X-particles of dark energy, called the X-sea. The X-particle accelerates the expansion of universe [2], sets the maximum speed (c) of any matter, and creates the ubiquitous gravitational field and the hierarchical inertial frames of reference [3]. It is the cause of the uncertainty principle, the wave-particle duality, and paradoxes such as the double-slit experiment and the quantum entanglement [4]. Both X-theory and general relativity use Lorentz transformation. The predictions of general relativity that have been confirmed in observations and experiments are still valid in X-theory. However, the repulsive force of dark energy exerted on the moving object creates a fundamental difference in physics. As in twin paradox, there is a hierarchical inertial frames of reference of the universe. The outbound twin's clock would go slower than inbound twin's clock depending on the repulsive forces exerted on the twins.

In X-theory, the initial state of the universe was not a singularity. There was some form of dark energy where the net repulsive force is proportional to energy density. If the distance between X-particles approaches to zero, repulsive force will increase to infinity, which will prevent the universe from being at the singularity. Inside the black hole, no singularity is predicted either. Matters such as X-particles cannot flow into a certain point or line, because it would need to overcome the infinite amount of repulsive forces. Instead, a strong X-gravitational field will be formed that most particles and electromagnetic radiation such as light will be attracted to the small core volume. There will be a certain limit that black holes can accommodate particles and objects due to repulsive forces of dark energy. There is no distortion of time and space either. As in twin paradox, biological aging is not the same as clock time-keeping. Every object has a state of motion relative to hierarchical inertial frames of reference formed by X-particles. The time and space in one inertial frames could be transformed to other inertial frames by Lorentz equation.

The main cause of anomalies in quantum mechanics is postulated to be dark energy. Thus many parts of classical mechanics would be valid in quantum mechanics if we add dark energy, spacetime, and Lorentz transformation into the model. The current popular approaches to the problem of quantum gravity are string theory and loop quantum gravity. At this point of time, unfortunately, it is not clear how to define the relationship between the X-theory and other quantum gravity theories, which needs further research.

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