Origin of the Gravitational Force

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Abstract The gravitational force is extremely important because it dominates the formation and evolution of the universe. However, its physical origin and intrinsic nature have not been clearly comprehended for a long time. Certain observed phenomena, along with the newly discovered by Hubble and James Webb telescopes, cannot be explained well by current theories. Furthermore, general relativity and quantum mechanics, which are mainstream theories explaining the gravitational force, are ultimately incompatible with each other. This situation strongly points to the need for a better or novel theory of the gravitational force. Here, based on classical space-time view, a different but solid understanding of the gravitational force is introduced. The author has realized that the gravitational force originates from none other than the electric force and is synthetic electric force produced by a large number of electric charges. Generally speaking, in most objects, there are a large number of free and potentially induced electric charges. Due to various reasons, including unavoidable fluctuations of microscopic particles, non-uniform charge distribution in the object is normal. Earth is typically such an example. The non-uniform charge distribution within an object will almost certainly turn that object into an electric dipole. Thus, almost any object can be regarded as an electric dipole, resulting in any two objects attracting each other. This is the true origin of the gravitational force. This understanding can solve or explain confusing problems or phenomena simply and effectively, such as dark matter, dark energy, flat galaxy and filamentary nebula. This understanding also naturally unifies the gravitational and electromagnetic forces.

Keywords: gravitational force; dark matter; dark energy; unification of the gravitational and electromagnetic forces; classical space-time

Introduction

Physics is the scientific study of matter motion and force interaction basically. Among the four fundamental forces of nature, the gravitational force is the most significant for the macrocosm because it dominates the formation and evolution of the universe. Without gravitational force, there would be no Earth and universe.

However, what is the gravitational force? What are its physical origin and intrinsic qualities? These questions are not yet fully explained. From Newton theory of gravity to Einstein general relativity, and then to Higgs particle and field, the theories of the gravitational force are constantly developing. However, there are still discrepancies between observed phenomena and established theories. Furthermore, with scientific and technological progress, more inexplicable phenomena have been discovered. Compared to the other three fundamental forces, questions about the gravitational force are especially difficult because of its strange and mysterious behaviors.

For example, stars on the outskirts of galaxies move much faster than estimated based on their normal matter quantities [1]. Many galaxies within galaxy clusters move similarly. Thus, many people believe there is a huge amount of dark matter in the universe to provide required attractive forces. However, despite extensive searching, no any sign of the dark matter has been found.

Another example is the accelerated expansion of the universe [2]. Observations show that the velocity at which a distant galaxy recedes from the observer is continuously increasing with time. According to classical gravity theory, the universe should gradually reduce its expansion because the

gravitational force is attractive. Therefore, unknown dark energy must dominate the universe expansion. The concept of dark energy is more mysterious than dark matter and has not been discovered yet.

The Hubble Space Telescope has captured images of nebulae showing rope-like filaments [3]. The current explanation is that shock waves are very thin, appearing filamentous when the shells are viewed edge-on. However, why the shock waves are very thin and how so many shells are coincidentally viewed edge-on remain unanswered.

The James Webb Telescope has also astonishingly discovered that early-stage stars are still accumulating mass from surrounding clouds [4], which violates the popular theory of universe having a definite age and starting from an explosion because those stars born in the early-stage of the universe and so should be mature.

The current mainstream theories of the gravitational force are based on Einstein general relativity and quantum mechanics. Einstein believed gravitational force originates from space-time curvature [5], while quantum mechanics posits that the force comes from the exchange of quantum particles [6]. Because the general relativity describes gravity as a smooth, continuous distortion of space-time, but quantum particles are discrete and discontinuous energy packets. The general relativity is ultimately incompatible with the quantum mechanics. This contradiction makes the unification of the four fundamental forces of nature impossible.

To solve these problems, many inferences and hypotheses, including some unimaginable ones, have been proposed. Despite arduous efforts over a long time, the physical origin and intrinsic quality of the gravitational force still lack satisfactory answers. This situation strongly points to the need for a better or even novel theory to explain the gravitational force in other ways.

This paper introduces a different and solid understanding of the gravitational force. The author has realized that the gravitational force originates from none other than the electric force. The author indicates that, in fact, the origin of the gravitational force is not complicated but requires insight to recognize the truth through confusing appearances.

This new understanding regards any object as an electric dipole. Thus, the gravitational force between two objects is just the electrical attractive force. As the electrical attractive force of the electric dipole, the gravitational force has these properties: 1. The gravitational force is anisotropic because the dipole electric field extends only along the dipole moment direction; 2. The gravitational force strength depends on net electric charge quantities and the length of the electric dipole of the object, not only depends on the so-called mass of the object.

Based on this understanding, the aforementioned confusing problems and phenomena can be solved and explained simply and effectively. The flat galaxies and filamentary nebulae are caused by gravitational force anisotropy. The ultra-fast movements of the stars on galaxy outskirts and galaxies within galaxy clusters, or the increasing velocity of the distant galaxy are kept or produced by increased or increasing gravitational forces. The slow growths of the early-stage stars are due to decreased gravitational forces. Note that the gravitational force strength of an object may change with the electric charge distribution in that object and not solely dependent on the object mass.

This new understanding is based on the classical space-time view and agrees with actual observations and normal thinking. The strange behaviors of the gravitational force can be completely understood with common sense, and do not need to be explained by unusual speculations or even unimaginable whimsies. Below, this new understanding will be introduced in detail.

Observation of the Gravitational Force

In the physics textbook, there is a description of the early discovery of electric charge and the attractive and repulsive forces between two charges [7]. As early as 600 BC, the ancient Greeks discovered that if amber was rubbed, it would attract other light objects, such as wool. Today we know that the amber has acquired net electric charges or has become "charged," and these net charges on the amber would attract the wool. When we rub a plastic rod with fur and rub a glass rod with silk, you can find that the rubbed plastic rod and rubbed glass rod all have become "charged", and then they can attract other light objects.

In experiments involving rubbing a plastic rod with fur and rubbing a glass rod with silk, we can see that a plastic rod can be attracted by a glass rod. However, two plastic rods rubbed with fur, or two glass rods rubbed with silk, repel each other. Today we know there are two kinds of electric charges. They are negative and positive, respectively. Rubbing the plastic rod with fur produces negative charges, while rubbing the glass rod with silk produces positive charges. After rubbing, the fur and silk also become "charged." When the signs of the net charges on the rods are the same, the rods repel each other. When the signs are opposite, the rods attract each other. Today we know that the signs of the net charges on the rubbed plastic rod and silk are negative. The signs of the net charges on the rubbed glass rod and fur are positive.

When you see wool being attracted by "charged" amber, you need to consider more. The wool is not rubbed with any material, thus, it has not acquired any net charge. An "uncharged" object should be electrically neutral and should not be attracted or repelled by a "charged" object. So, why does the "charged" amber attract the "uncharged" wool?

This involves the generation and influence of induced electric charges. In an object, there are free electric charges. If an external electric field exerts a force on the object, the free charges will move, changing the distribution of the total charges in the object. This change in charge distribution affects the electric fields inside and outside the object. Thus, the regional distribution of the charges in the object and the spatial distribution of the field out the object will affect each other and the last equilibrium of the charge and field distributions will be determined by both of the electric charges and electric field.

Additionally, many objects contain polar molecules having equal amounts of positive and negative charges but a lopsided distribution. In these molecules, the excess positive and negative charges are concentrated on opposite sides, making the molecule become an electric dipole. The dipole moment direction may change with the external electric field. In the object, there are also non-polar molecules. Under the external electric field, the positive and negative charge centers of these non-polar molecules may shift from a concentric status to a non-concentric status, causing these non-polar molecules to become polarized polar molecules. Furthermore, electrically neutral atoms will also produce atomic polarization under the external electric field, with the positive and negative charge centers shifting from a concentric status to a non-concentric status.

The movements of free charges, the changes of dipole directions of polar molecules, and the polarizations of non-polar molecules and atoms will form induced electric charges in the object. These induced charges will alter the regional distribution of electric charges in the object and the spatial distribution of electric fields in and out the object.

The amount of free and induced electric charges depends on the number of molecules and atoms in the object. Thus, generally speaking, when an object has more molecules and atoms, this object may have more mass and more free and induced electric charges.

Under an external electric field, the redistribution of electric charges, including free and induced charges in the object, is the key reason that "charged" amber can attract "uncharged" wool. Regardless of whether an object is electrically neutral or has net positive or negative charges, its electric charge distribution will change under the influence of an external electric field.

Suppose the "charged" amber is close to the "uncharged" wool. If the amber has net positive charges, it will exert a positive electric field on the wool, attracting the free negative charges in the wool to the side close to the amber. Since the amounts of positive and negative charges in electrically neutral wool are equal due to conservation of electric charge, the increase of net negative charges near the amber equals the increase of net positive charges far from the amber. Because the net negative charges are closer to the amber than the net positive charges, the attractive force of the amber on the net negative charges is slightly larger than its repulsive force on the net positive charges. Thus, the net force exerted by the amber on the wool is attractive, enough to lift light objects like wool, as shown in figure 1.
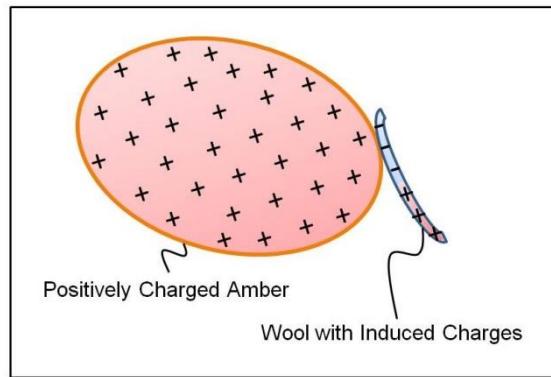
Figure 1. The positively "Charged" amber picks up "uncharged" wool. The net positive and net negative charges are distributed in the red and blue regions, respectively.

At the same time, under the positive electric field of the amber, the distribution center of all induced net negative charges will be close to the amber, while the distribution center of all induced net positive charges will be far from the amber. The location difference between these two induced charge centers makes the amber attractive force slightly larger than its repulsive force to the wool too, helping to pick up the wool.

The attractive force between the amber and wool is a synthetic electric force produced by a large number of electric charges in both the amber and wool. Although the wool is small, it contains a significant number of molecules and atoms, and thus a large number of free and induced electric charges.

If the amber is replaced by a negatively "charged" plastic rod, it can also pick up the "uncharged" wool. In this case, the rod will attract net free positive charges and distribution center of induced positive charges close to the rod, and will repel net free negative charges and distribution center of induced negative charges far from the rod. Thus, the net force of the plastic rod on the wool will remain a small attractive force, sufficient to lift the lightweight wool. Therefore, whether an object has net positive or net negative charges, the "uncharged" wool will always be attracted to the "charged" object.

The author explained why a small "uncharged" paper piece can be attracted by a "charged" object in an electromagnetism examination at university with such details while young, but did not think further at that time. Thus, the author was unaware that understanding this phenomenon approached the realization of the origin of the gravitational force.

Origin of the Gravitational Force

From understanding that a "charged" object can attract an "uncharged" object to understanding origin of the gravitational force, that is, to realizing that the gravitational force can originate spontaneously between two "uncharged" objects, the key step is to recognize that non-uniform charge distribution, that is, the regions with net positive and net negative charges can emerge spontaneously in an "uncharged" or initially electrically neutral object.

In an electrically neutral object, an initial variation in charge distribution can disrupt charge distribution uniformity, causing net positive or negative electric charges to appear. Many factors can cause such variation, including different movements of free electric charges, different thermal vibrations of polar and non-polar molecules and atoms, various collisions among microscopic particles, different densities of polar and non-polar molecules and atoms, and different physical and chemical characteristics of different regions within the object including substance composition, state, form, temperature, pressure, fluidity, and electric and thermal conductivity, etc. These myriad causes make the presence of net electric charges in an object unavoidable and normal. The common cognition that the electric charge distribution in an "uncharged" object is always absolutely uniform is wrong.

For example, Earth is a typical object with spontaneous non-uniform distributions of the electric charges and fields due to various substance compositions with different physical and chemical

properties in Earth interior. Furthermore, these non-uniform distributions are continuously changing. The Earth magnetic field results from the continuous flow of a huge number of electric charges. Measurements have also shown that the Earth has a complex, non-uniform electric field distribution on the ground [8], which can serve as a navigation map. This map is possibly more reliable than GPS, as it cannot be destroyed.

The events occurring on Earth may occur on other celestial bodies as well. Moreover, the events occur in large objects, like Earth, may also occur in small objects, such as wool. For free electrons, polar molecules, non-polar molecules and atoms, small objects like wool are sufficiently large.

Therefore, when two objects approach each other, if object 1 has a region with net electric charges, it will produce a net electric field affecting object 2. This external electric field, even if weak, will alter the charge distribution in object 2 from uniform to non-uniform, even if this change is initially small. The non-uniform distribution in object 2 will generate a new electric field to exert back on object 1. Consequently, the non-uniform charge distributions in both objects will gradually increase, resulting in stronger and stronger electric fields both within and outside the two objects. These electric fields will interact each other. Thus, the electric interaction force between the two objects can start from nothing and grow from weak to strong.

There is, of course, a limitation on the increase of this electric interaction force. The net negative charges in one or more regions will attract the net positive charges in other regions within each object. With continual moving of the free charges within each object, the amounts of net positive and negative charges in different regions increase, enhancing the repulsive forces to the charge with the same charge signs to enter these regions further. That is, these increased forces will gradually reduce farther moving of the free charges in each object. Similar limitations apply to two kinds of induced charges from polar molecules and non-polar molecules and atoms in each object. Eventually, the electric charge and field distributions in the two objects will reach equilibrium states, and the electrical interaction force between the two objects will be stabilized.

Such electrical interaction force can create between two objects even they are initially electrically neutral. These objects can range from as large as galaxies and galaxy clusters to as small as molecules and atoms because even the atoms can become tiny electric dipoles when they are polarized to have separated positive and negative charge centers. The following analysis and calculation will show that such electrical interaction force is attractive force, and is essentially the gravitational force. It is the origin of the gravitational force.

Understanding how an attractive force can arise spontaneously between two initially electrically neutral objects may be challenging. However, if a non-uniform charge distribution can be induced in electrically neutral wool by an external electric field, why cannot a non-uniform charge distribution be induced in a neutral object by inevitable charge variation? Furthermore, if a "positively charged" amber or "negatively charged" plastic rod can attract "uncharged" wool, why cannot the Earth, which is a huge electric dipole (see explanations below), attract the "uncharged" objects on its surface, including every one of us? Compared to an amber or plastic rod and wool, a person to the Earth is much smaller than wool to the amber or plastic rod. Regardless of whether the electric field exerted by the Earth on a person is positive or negative, it is similar to whether a positively charged amber or a negatively charged plastic rod is close to wool, the wool will be attracted to the charged amber or plastic rod, and therefore, the person will always be attracted to the Earth.

In reality, the spontaneous appearances of net electric charges and non-uniform charge distribution are common in initially electrically neutral objects. The misconception about this has long prevented people from discovering the true origin of the gravitational force.

The author emphasizes that almost all of the non-uniform charge distribution in an object will make that object become an electric dipole, because, when an object has non-uniform charge distribution, it is almost impossible that the center of the total net positive charge distribution and the center of the total net negative charge distribution in the object are exactly at the same point.

The creation process of the electric interaction force between two objects cannot be seen visibly because the moving of free charges and the polarization of polar molecules, non-polar molecules and atoms are moving of electrons and shift of electric charge centers. These movements and shifts have

very fast speeds, possibly close to the light speed. Therefore, because these processes can start from nothing, grow and finish instantly and cannot be seen visibly, the gravitational force is strange and mysterious.
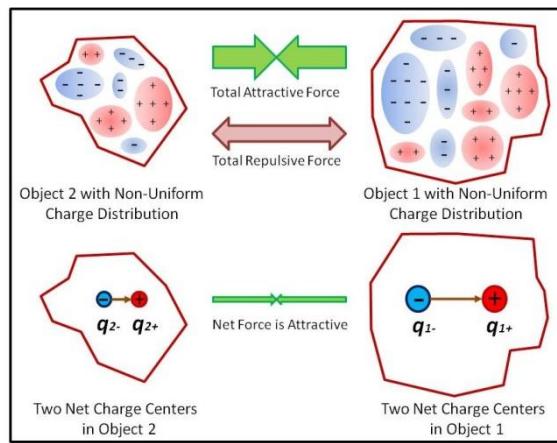
Figure 2. The electric interaction force between two objects with non-uniform charge distributions. The total net positive charges and total net negative charges in each object are regarded as concentrated in their charge centers, represented by red and blue circles with charge amounts q_{1+}, q_{1-}, q_{2+} and q_{2-}, respectively.

In interactions involving a large number of positive and negative electric charges, most electrical attractive forces are canceled by electrical repulsive forces due to the opposite signs of the electric charges, as shown in figure 2. Thus, the net electric interaction force is weak, and so although the gravitational force is the electric force, its strength is much smaller than the electric force. This is why the gravitational force strength is about 37 orders of magnitude smaller than the electric force strength, even though both have the same extremely long interaction distances. This is another difficulty for many people to understand the strange behavior of the gravitational force.

More atoms and molecules in an object can provide more free and induced electric charges and can produce a stronger electric field and electrical attractive force. It is why the object with more mass can produce larger gravitational force.

Currently, what is the mass? This question has not been answered clearly either. In physics, the mass concept has two meanings: one is gravitational mass, and the other is inertial mass. Based on the new understanding of the gravitational force, an object gravitational mass expresses the attractive force strength exerted on the object by the synthetic electric field of the total Earth electric charges when the object is motionless relative to the Earth. The object inertial mass expresses the attractive force strength exerted on the object by the synthetic electric field of total electric charges distributed in a space in which the object is moving. Thus, this new understanding provides the real physical explanation for the Einstein mass-energy conservation law

$E = mC^2$.

Because both the gravitational mass and the inertial mass of an object are expressions of the interaction force strengths exerted on an object, so the energy change of an object caused by force and motion will naturally cause so-called mass of that object to change.

A hint that the gravitational force is the electric force is that the propagation speed of gravitational waves equals the speed of light. It is known that the speed of light is the speed of electromagnetic wave propagation. Therefore, since the gravitational field is the electric field, the gravitational wave propagation speed is naturally equal to the speed of light.

Calculation of the Gravitational Force

In an object, the non-uniform distribution of electric charges may be very complicated, making the analysis and calculation of the produced electric fields difficult. To simplify this, two net "charge centers," similar to the "mass center" used in mechanics, are defined.

Regardless of the complexity of the net positive and net negative charge distributions, all electric forces generated by all net positive charges can be synthesized into a synthetic positive electric force. The point at which this force is exerted on another object is the net positive "charge center." Similarly, the net negative "charge center" is defined.

With this simplification, any object with non-uniform charge distribution can be regarded as having a net "positive charge center" and a net "negative charge center." All net positive charges are considered concentrated at the "positive charge center," and all net negative charges are considered concentrated at the "negative charge center." As emphasized above, because these two charge centers are almost impossibly at the same point, nearly any object with non-uniform charge distribution can be regarded as an electric dipole.

The theoretical electric dipole is a pair of two point electric charges with equal magnitude $| q |$ and opposite signs, where $| q |$ is the absolute value of charge q. A small distance l is between the two point charges. The electric dipole moment $\vec{p}$ is the product of the distance l and the charge q.

$$\vec{p} = q\vec{l}. \tag{2}$$

where $\vec{P}$ and $\vec{l}$ are vectors. The direction of the dipole moment $\vec{P}$ is from the negative point charge to the positive point charge.

Sometimes, the distance between the "positive charge center" and the "negative charge center" in an object may not be small. However, if the size of the object is much smaller than the scale related to the problem being considered, such as considering the attraction between a planet and a star in the universe, the size and shape of the object are less important. Thus, the distance between the positive and negative "charge centers" in an object may be treated as small, so the object with a non-uniform charge distribution may be reasonably regarded as an electric dipole.

The electrical field strength $\vec{E}$ of the electric dipole at the distance of R is [9]

$$\vec{E} = \frac{1}{4\pi\epsilon_0 R^3}[3(\vec{P}\cdot\vec{R})\vec{R} - \vec{P}]. \tag{3}$$

In Eq. (3), $\vec{R}$ is unit distance vector along the R direction. ϵ_0 is the electric constant. From Eq. (3), we know that when the direction of the vector $\vec{R}$ changes, the electric field strength $\vec{E}$ changes too. When the direction of $\vec{P}$ is the same as or opposite to the direction of $\vec{R}$, the electric field strength $\vec{E}$ becomes E_S or E_O,

$$E_S = \frac{2P}{4\pi\varepsilon_0 R^3} \tag{4}$$

$$E_O = \frac{-2P}{4\pi\varepsilon_0 R^3} \tag{5}$$

The E_S in Eq. (4) is positive, which expresses a repulsive force away from the dipole to a positive point charge. The E_O in Eq. (5) is negative, which expresses an attractive force towards the dipole to a positive point charge. When the direction of the dipole moment is perpendicular to the direction of $\vec{R}$, the electric field strength $\vec{E}$ becomes E_P.

$$E_P = \frac{-P}{4\pi\varepsilon_0 R^3} \tag{6}$$

The E_P in Eq. (6) is negative. Please note that E_P is a deflective force.

Then, a problem arises: if the electric field strength of an object with non-uniform charge distribution is not isotropic, why we have not observed that the gravitational force between two objects varies significantly with their relative direction? For instance, many planetary orbits around stars are nearly circular.

The reason is that while the electric field of an electric dipole may exert repulsive, attractive, or deflective forces on another electric dipole, in most cases, the repulsive and deflective forces will quickly become attractive force. When the interaction between two electric dipoles is repulsive, both dipoles are in states of highest electric potential energy, which are unstable. Any change in the charge distribution of one object will produce a deflective force between the two dipoles. This deflective force rotates the dipoles, eventually making the gravitational force between them attractive.

However, in some cases, the gravitational force between the two objects is still affected by their relative direction, which is one of the reasons why some planetary orbits around stars are elliptical.

Below, the interaction force between two electric dipoles is calculated. First, considering the case when the directions of two dipole moments are the same. In figure 3, the first dipole moment $\vec{P}_1$

consists of positive pinot charge q_{1+} and negative point charge q_{1-}. The second dipole moment $\vec{P}_2$ consists of positive pinot charge q_{2+} and negative point charge q_{2-}. The length of the first dipole moment $\vec{P}_1$ is r_1. The length of the second dipole moment $\vec{P}_2$ is r_2. The distance between the centers of two dipoles is R.

From Eq. (3), the first electric dipole will produce the electrical field $\vec{E}_1$ at the distance R from its center

$$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0 R^3}\left[3\left(\vec{P}_1 \cdot \vec{R}\right)\vec{R} - \vec{P}_1\right]. \quad (7)$$

In the electrical field $\vec{E}_1$, the positive point charge q_{2+} of the second dipole will feel a force $\vec{F}_{q2+}$ as

$$\vec{F}_{q2+} = q_{2+}\vec{E}_1 = \frac{2q_{2+}\vec{P}_1}{4\pi\varepsilon_0(R-0.5r_2)^3} \quad (8)$$
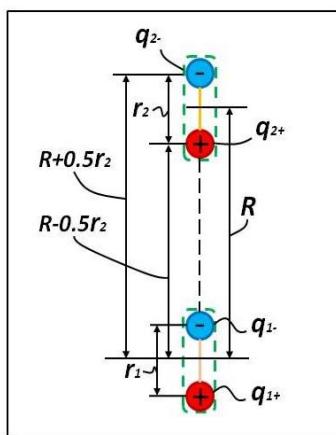
Figure 3. Interaction forces between two dipoles when dipole moment directions are the same.

The direction of force $\vec{F}_{q2+}$ is along the direction of $\vec{R}$. The negative point charge q_{2-} of the second dipole will feel a force $\vec{F}_{q2-}$ as

$$\vec{F}_{q2-} = q_{2-}\vec{E}_1 = \frac{2q_{2-}\vec{P}_1}{4\pi\varepsilon_0(R+0.5r_2)^3}. \quad (9)$$

The direction of force $\vec{F}_{q2-}$ is also along the direction of $\vec{R}$.

Because the absolute values of q_{1+} and q_{1-} are equal, and the absolute values of q_{2+} and q_{2-} are also equal, when $R \gg r_1$ and $R \gg r_2$, the total force felt by the second dipole in the electric field $\vec{E}_1$ is $\vec{F}_T$ approximately

$$\vec{F}_T = \vec{F}_{q2+} + \vec{F}_{q2-} \doteq \frac{6r_1r_2}{R^2}\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{R^2}\vec{R}. \quad (10)$$

In Eq. (10), if $\frac{6r_1r_2q_1}{R^2}$ is replaced by m_1, $\frac{6r_1r_2q_2}{R^2}$ is replaced by m_2, and $\frac{1}{4\pi\varepsilon_0}$ is replaced by gravitational constant G, then Eq. (10) becomes Newton's gravitational law

$$\vec{F}_G = G\frac{m_1m_2}{R^2}\vec{R}. \quad (11)$$

We can see that the physical essence of the mysterious mass is just the electric charges. In other words, the mass is another expression of the amount of the electric charges.

Compare Newton's law of the gravitational force F_G with Coulomb's law of the electric force F_E

$$\vec{F}_E = K\frac{q_1q_2}{R^2}\vec{R} \quad (12)$$

We can see that their expressions are very similar. Eq. (11) expresses the attractive gravitational force generated by two point-like objects with masses of m_1 and m_2. Eq. (12) expresses the attractive electric force generated by two point electric charges of q_1 and q_2. G and K are proportionality constants whose numerical values depend on the system of units used. R is the distance between two mass centers or two charge centers. $\vec{R}$ is unit distance vector along R direction. If two charges in Eq. (12) are replaced by two masses in Eq. (11), then Eq. (12) becomes Eq. (11). Of course, because m_1 and m_2 are mass, and q_1 and q_2 are electric charges, the dimensions of the constants G and K are naturally different, and the magnitudes of the constants G and K differ greatly because the

gravitational force is produced by a large number of electric charges, and the most of the electric forces produced by electric charges have been cancelled since the electric charges have opposite signs.

The striking similarity between Eq. (11) and Eq. (12) strongly hints that the gravitational force is the electric force, because if the natures of two physical forces are different, their expressions should be significantly different. Where else can we find such similarity between the expressions of two different physical forces?

When the directions of two dipole moments are opposite or perpendicular, the interaction forces between two dipoles become repulsive or deflective because both of the dipoles are pushed by repulsive electric fields, expressed by Eq. (4), or twisted by deflective electric fields, expressed by Eq. (6).

However, as explained above, in most cases, two interacting electric dipoles cannot push or twist each other for long. As soon as an electric dipole is affected by a deflective force, even if small, its dipole moment direction will rotate and eventually align with the direction of that force. The rotation of the electric dipole doesn't require the rotation of the real object physical body. It only needs a change in the distribution of net electric charges, including free and induced charges in the object. Such changes are very fast and cannot be seen visibly. This explains why the gravitational force is always attractive. Thus, when considering the interaction force between two objects, because the directions of two electric dipoles are almost always the same, the interaction force, that is, the gravitational force between the two objects, can be expressed by Eq. (10) only.

When three objects interact with each other, the free and induced charges in each object are redistributed in response to the electric fields generated by the other two objects. If each object is simplified as an electric dipole, it will interact with the electric dipoles of the other objects. Thus, the redistribution of charges in each object may be regarded as forming two electric dipoles. Each dipole in one object responds to an external dipole in another object, leading to the analysis of interactions among six electric dipoles. When more objects are involved, the gravitational force analysis becomes more complex. However, the redistribution of charges in each object may still be regarded as forming multiple electric dipoles, each responding to a dipole in another object.

Eq. (10) expresses the interactional electric force between two electric dipoles when the dipoles have the same direction. This electric force is the gravitational force between two objects. According to Eq. (10), the gravitational force has the following properties:

First, since the gravitational force is produced by electric charges q_1 and q_2, the gravitational field is actually the electric field.

Second, the gravitational force strength depends on the force direction, meaning that the gravitational force is anisotropic.

Third, replacing $\frac{6r_1r_2q_1}{R^2}$ with m_1 and replacing $\frac{6r_1r_2q_2}{R^2}$ with m_2, because in most cases, $R \gg r_1$ and $R \gg r_2$, so the magnitudes of m_1 and m_2 are much smaller than the magnitudes of q_1 and q_2. This is why, although the gravitational force is the electric force, the strength of the gravitational force is much smaller than the strength of the electric force.

Fourth, the values of r_1, r_2, q_1 and q_2 in Eq. (10) are not fixed because they are determined by charge distributions in two objects. Since variations of charge distributions in two objects can change the values of r_1, r_2, q_1 and q_2, the gravitational force between two objects is not fixed even their so-called masses don't change.

These properties make the gravitational force exhibit strange and mysterious behaviors, causing confusing phenomena observed in the universe. Some of these phenomena have puzzled humans for a long time. However, by using new understandings of the gravitational force introduced here, these confusing phenomena can be explained simply and effectively. On the other hand, these phenomena may be regarded as indirect evidences of the correctness of the introduced understanding.

Truths of the Confusing Phenomena

1. Causes of the Flat Galaxies and Filamentary Nebulae

So far, almost all observed celestial systems, including solar system, galaxies, and galaxy clusters, have approximately flat spherical shapes. Such shapes are caused by the anisotropy of the

gravitational field as expressed by Eqs. (3), (4), (5), and (6). Because most celestial bodies can be regarded as electric dipoles, and the attractive force of the electric dipole is only along the direction of the dipole moment, any two celestial bodies are attracted to each other along a line. Many lines compose a common plane. When numerous celestial bodies are attracted to each other and to a stronger attractive center simultaneously, they move closer along various lines toward the attractive center, tending to follow a common plane. Thus, the numerous celestial bodies form an approximately flat spherical spatial distribution from their previous random spatial distribution.

The Hubble Space Telescope has discovered the Filamentary Nebulae (also called as the Veil Nebulae or Cirrus Nebulae) [1]. These nebulae have immense sizes of more than 130 light-years at a distant location of about 2,400 light-years. This is one of the most astonishing discoveries in the universe recently. These nebulae have asymmetric and non-homogeneous structures, including filaments and loops. Remarkably, these structures challenge the consensus of the universe being homogeneous. However, these structures just prove the new understanding about the gravitational force, that is, the gravitational force is anisotropic. The electric field of the electric dipole is effective only along a certain direction, or along a plane when the object rotates. As a result, the numerous celestial bodies, including gas, dust, planets, stars, galaxies, and galaxy clusters, will more likely form filaments and loops of huge sizes.

2. Misconception of Dark Matter

At present, dark matter is almost a basic consensus regarding the universe constitution. Otherwise, how can we explain why the faraway spiral arms of the giant galaxy and the galaxies on the outskirts of the galaxy cluster don not collapse when they move at much faster speeds? According to current gravity theory, the celestial bodies including fast-moving stars in the spiral arms and the galaxies on the galaxy cluster outskirts must have much greater masses to produce required attractive forces. Since the predicted matter cannot be found, a large quantity of unseen dark matter must exist in these spiral arms and cluster outskirts. However, despite many attempts, no any sign of dark matter has been found.

The new understanding of gravitational force can solve this difficult problem easily and effectively. According to the electric dipole model described above, the gravitational force between two objects can change with object dipole lengths r_1 and r_2, and net electric charges q_1 and q_2 in the objects as expressed by Eq. (10). The values r_1, r_2, q_1 and q_2 are determined by charge distributions in the objects. Many factors, including substance state, temperature, pressure, density, conductivity, and mutual interactional electric field strength, can change the charge distributions in the objects and increase the object attractive forces. Thus, the celestial bodies in the galaxy spiral arms and the galaxies on the galaxy cluster outskirts can have much larger attractive forces than estimated without much greater masses, allowing them to rotate at faster speeds without collapsing. There are no dark matters in the universe because they are not required to maintain the existence of the evolving universe.

3. Misconception of Dark Energy

Dark energy has almost become a basic consensus regarding the universe composition too. The reason is that a special kind of unseen energy is required to explain why the distant galaxies are moving away from us at increasing speeds.

First, we must determine if the entire universe is expanding at accelerated pace. Celestial bodies, including planets, stars, galaxies, and galaxy clusters, move in different directions and at different speeds including at accelerated speeds. Thus, some of them move away from each other, while others move close to each other. However, these diverse movements, including accelerated ones, differ from the concept of universal expansion or accelerated expansion.

Even if some parts of the universe are expanding at accelerated rates, the new understanding of the gravitational force has indicated that the strength of an object gravitational force may change including continually change with the change of electric charge distribution within the object. Thus, the gravitational force could become stronger including continually becoming stronger than the

estimated. Therefore, parts or even whole of the universe might be moving away from us at accelerated speeds, without requiring dark energy to explain the accelerated expansion. There is no dark energy in the universe.

4. Slow Growth of Early-Stage Stars

Also based on a new understanding of the gravitational force, an object gravitational force, on the one hand, may be stronger than the estimated based on its normal mass. On the other hand, an object gravitational force may be weaker than the estimated based on its normal mass. Thus, when the gravitational force is weaker than the estimated, the growths of the stars will slow down, resulting in unexpected baby stars still existing somewhere in the universe.

5. Compatibility of the Gravitational Force Theory and the Quantum Mechanics

Because the gravitational field is the electric field, the gravitational force can be unified with the electromagnetic force completely. Furthermore, if the electric field can be well described by quantum mechanics, the gravitational field can be as well described by quantum mechanics. Therefore, the new theory of the gravitational force is fully compatible with the quantum mechanics. In addition, the satisfying unification of the gravitational and electromagnetic forces opens a hopeful door for the ultimate unification of the four fundamental forces of nature.

Conclusions

This paper introduces the origin of the gravitational force, that is, the gravitational force actually originates from the electric force. Due to unavoidable non-uniform charge distribution within objects, almost any object is an electric dipole. Thus, any two objects will attract each other, which is the true origin of the gravitational force.

The theoretical calculation expression for the gravitational force is given, and the special properties of the gravitational force are discussed. This new understanding can easily and effectively solve and explain the confusing problems and phenomena, such as dark matter, dark energy, flat galaxy shapes, filamentary nebulae, and slow growth of the baby stars. Based on this new understanding, the gravitational force can naturally unify with the electromagnetic force, and opening a hopeful door for the ultimate unification of the four fundamental forces of nature.

The explained phenomena may be regarded as indirect proofs of this new understanding. The author is confident in this theory and welcomes discussions on it.

Acknowledgments. The author acknowledges Joyce Liu at University of Rochester School of Medicine and Dentistry for discussion and help to writing this article.

Disclosure: This paper is written partially based on the specifications recorded in the following patent applications: 1. Canada patent application titled "Methods of Changing Gravitational Force and Producing Electric Current", which was filed on August 8, 2024 (Project Publication Date: 02/08/2026) with application number: 3,251,371; 2. USA patent application titled "Methods of Changing Gravitational Force and Producing Electric Current", which was filed on August 9, 2024 (Project Publication Date: 02/12/2026) with application number: 18/799,600. The author declares no competing interests in this work.

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