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Origin of Gravitational Force—Model of Inductively Oriented Electric Dipole with Dynamically Self-Calibrating Constant Attraction

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Abstract

Gravitational force is extremely important because it dominates the formation and evolution of the universe. However, its physical origin and intrinsic qualities have not been clearly understood for a long time. Certain observed phenomena, along with those newly discovered by the Hubble and James Webb telescopes, cannot be well explained by existing theories. Furthermore, general relativity and quantum mechanics, which are the current mainstream theories explaining gravitational force, are incompatible with each other. This situation strongly points to the need for a better or even novel theory of gravitational force. Here, based on the classical space-time perspective, a different yet robust understanding of gravitational force is introduced. The author has realized that gravitational force originates from none other than the electric force. But it is a synthetic electric force produced by a large number of electric charges, including both of positive and negative charges, and thus shows very different characteristics from a simple electric force caused by either positive or negative charges. In any object, there are a large number of free and inducible net electric charges. Due to various macroscopic and microscopic reasons, the electric charge distribution in any object is non-uniform and directional, since in most cases, the centers of positive and negative charges of this non-uniform distribution cannot be exactly at the same point. Thus, almost any object becomes an electric dipole inherently. When an object exists independently, its dipole direction is randomly oriented, resulting in its overall electrical neutrality statistically. However, when two objects interact, their charge distributions change under the influence of the electric field generated by the opposing object's internal charges. This change intensifies through continuous interactions, eventually aligning dipole directions of two objects along a line. Furthermore, through a dynamically self-calibrating process, the directions of two objects' dipoles can always point toward each other, regardless of whether the two objects are stationary, moving, or orbiting each other. Therefore, although the force direction of an electric dipole is anisotropic, because the dipole direction, determined by directional non-uniform charge distribution, can change dynamically and quickly, an object's dipole can always maintain attraction to other object's dipole, similar to an object exhibiting isotropic attraction to another object. The multiple electric dipoles, or even multiple groups of electric dipoles can mutually attract each other too, since multiple dipoles or multiple dipole groups can have a combined directional non-uniform charge distribution too. This is the true origin of gravitational force. Calculations have shown that, under certain conditions, the strength change rate of gravitational force deduced from the dipole model theory closely follows the law of inverse square of distance. This understanding can effectively explain observed phenomena, including confusing ones, such as flat galaxies, filamentary nebulae, the formation of the Solar System and the Milky Way galaxy, the unusual trajectories of 'Oumuamua and 3I/ATLAS, as well as dark matter and dark energy. This understanding also naturally unifies gravitational and electromagnetic forces and opens a key door for the final unification of the four fundamental forces of nature.

Keywords: gravitational force; formations of the solar system and milky way galaxy; dark matter; dark energy; unification of the gravitational and electromagnetic forces; classical space-time

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Introduction

The study of force and force interactions is a core subject in physics research, and physics serves as the most important foundation of modern science. Among the four fundamental forces of nature, gravitational force is the most significant for the macrocosm because it governs the formation and evolution of the universe. Without gravitational force, neither Earth nor the universe would exist.

However, what is the gravitational force? What are its physical origin and intrinsic qualities? These questions have not yet been clearly explained. From Newton's theory of gravity to Einstein's general relativity, and then to the Higgs particle and field, theories of gravitational force are constantly developing. However, there are still discrepancies between observed phenomena and existing theories. Furthermore, with scientific and technological progress, more inexplicable phenomena have been discovered. Compared to the other three fundamental forces, questions about 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 exhibit similar behavior. Thus, some people propose that a large amount of dark matter is present to provide the necessary attractive forces. However, despite extensive searching, no sign of dark matter has been found.

Another example is the accelerated expansion of the universe [2]. It seems that the velocity at which a distant galaxy recedes from us is continuously increasing. Therefore, unknown dark energy is thought to dominate the universe. Otherwise, how can we explain the accelerated expansion of the universe? However, similarly, no dark energy has been detected so far either.

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 their shells are viewed edge-on. However, why the shock waves are so thin and how so many of their shells are coincidentally viewed edge-on remain unanswered.

The James Webb Telescope has astonishingly discovered rapidly matured massive galactic structures that should not have formed in the early stages of the universe [4]. On the other hand, some distant stars are still accumulating mass from surrounding clouds [4]. These phenomena contradict the theory of the universe having a definite age starting from an explosion, as the maturities of these stars and galaxies should be consistent with the universe's age.

In recent years, some strange comets have entered the solar system, such as ‘Oumuamua[1] to ‘Oumuamua[3], and 3I/ATLAS. Their trajectories are so unusual that they cannot be explained by Newton’s law of universal gravitation.

The current mainstream theories of gravitational force are based on Einstein's general relativity and quantum mechanics. Einstein believed that gravitational force originates from the curvature of space-time [5], while quantum mechanics posits that it arises from the exchange of quantum particles [6]. General relativity describes gravity as a smooth, continuous distortion of space-time, whereas quantum particles are discrete and discontinuous energy packets. This makes general relativity incompatible with quantum mechanics. Additionally, this contradiction prevents the unification of the four fundamental forces of nature.

The study of the origin and nature of gravitational force has been a longstanding issue for humanity, especially since the time of Einstein. However, despite extensive efforts over a long period, the physical origin and intrinsic nature of gravitational force still lack satisfactory explanations. The various theories proposed for solving this issue, including mainstream ones, have not been entirely self-consistent, nor can they explain observed physical or astronomical phenomena. For example, general relativity cannot explain dark energy, dark matter, the accelerated expansion of the universe, and early cosmic inflation; superstring theory cannot explain the origin of the universe and initial conditions, dark matter, dark energy, and the accelerated expansion of the universe; and loop quantum gravity theory also cannot explain dark matter, dark energy, the accelerated expansion of

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the universe, cosmic microwave background anomalies, and phenomena related to black holes and extreme gravity. Therefore, these theories have not been fully accepted by the scientific community. This situation strongly requires a better or even novel theory to explain gravitational force effectively and satisfyingly, perhaps in different ways.

Among four fundamental forces of nature, only the electromagnetic force is clearly understood without dispute. As for the theories regarding the origin and nature of the other three fundamental forces, especially the general relativity theory, superstring theory, and loop quantum gravity theory, the author must objectively say that there are too much speculations involved.

In fact, the essence of nature is simple. As firmly believed by the greatest pioneer, Faraday, of the modern electromagnetic science, which is one of foundations of modern society. Nearly two hundred years ago (around 1850), Faraday attempted to link gravitational force and electromagnetic force, but did not succeed. However, his belief never wavered throughout his life: "The long and constant persuasion that all the forces of nature are mutually dependent, having one common origin, or rather being different manifestations of one fundamental power, has often made me think on the possibility of establishing, by experiment, a connection between gravity and electricity …no terms could exaggerate the value of the relation they would establish [7]."

Based on same faith, the author presents a new yet robust understanding of gravitational force, that is, the gravitational force originates from the electric force, but from a synthetic electric force generated by a large number of electric charges, including both of positive and negative charges. The behavior and characteristics of this synthetic force differ significantly from those of a simple electric force, generated by either positive or negative charges. The author also suggests that understanding the origin of gravitational force is not complex but requires insight to discern it through its misleading appearances.

This new understanding considers any object as an electric dipole when it interacts with another one, and any two electric dipoles will interact and ultimately attract each other. This electrical attractive force forms the gravitational force between any two objects. This attraction mechanism also applies to multiple dipoles or dipole groups, as each dipole or dipole group has a single or combined directional non-uniform charge distribution. Detailed analyses and calculations will demonstrate this. Because the gravitational force is the electrical attractive force of an electric dipole, the gravitational force has the following properties:

1. The gravitational force is essentially anisotropic because the dipole electric field extends only along the dipole moment direction.
2. The strength of the gravitational force depends on the net electric charge quantities and the dipole moment length of the object; it does not depend solely on the so-called mass of the object.
3. Due to a dynamically self-calibrating process, any object can always attract its surrounding objects, regardless of whether the object is stationary or rotates around it, as if any object has an isotropic attractive force.
4. Although the strength of the electric field of an electric dipole is inversely proportional to the cube of the distance from the dipole, under certain conditions, the strength chang rate of gravitational force deduced from the dipole model theory is still inversely proportional to the square of the distance from the object. Thus, the dipole model theory is highly consistent with the precise results measured by modern technology. This result reveals a truth: Newton's laws is a high-precision approximation of the real physical fact.

Based on this understanding, the aforementioned confusing phenomena can be easily explained. The flat galaxies and filamentary nebulae are caused by gravitational force anisotropy. The Solar System and Milky Way galaxy can operate stably because celestial bodies with heavy so-called masses can attract others through seemingly isotropic attraction. The ultra-fast movements of stars on the outskirts of galaxies and periphery galaxies within galaxy clusters are maintained by increased attraction forces. The possible continually increasing velocity of distant galaxies is produced by continually increasing attraction force, while the slow growth of distant stars is due to decreased

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attraction force. The strange trajectories of some comets entering the solar system are caused by unusual charge distributions within these celestial bodies.

Please note that the strength of an object's gravitational force may change with the electric charge distribution and is not solely dependent on the object's fixed so-called mass. This new understanding is based on the classical space-time perspective and substantially on traditional electromagnetic principle. Thus, the strange behaviors of gravitational force can be effectively understood with common sense. Below, this new understanding will be introduced in detail.

Observation of 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 [8]. 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 too.

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, will 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 on the rod, while rubbing the glass rod with silk produces positive charges on the rod. 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 of the net charges on the rods 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 think 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?

It is due to free charges move, as well as generation and influence of induced (inducted) net electric charges. In any object, there are numerous free charges, which consist of easily ionizable electrons and positive ions, and bound charges, which consist of polar molecules, non-polar molecules, and atoms. Polar molecules have equal amounts of positive and negative charges but with an uneven distribution. In these molecules, the excess positive and negative charges are concentrated on opposite sides, making the molecule an electric dipole.

The negative free charges come from orbital electrons moving in the outer orbitals of atoms. A small portion of these electrons is easily ionizable. The positive free charges consist of positive ions, which are incomplete atoms due to losing some orbital electrons. The negative free charges (electrons) have high mobility, while the positive free charges (positive ions) have low mobility and are essentially immobile, with much larger volume and mass than electrons.

In most objects, the number of free charges is far less than the number of bound charges. This is because only a small number of atoms are easily ionized, and only a small portion of electrons in each ionized atom can become free electrons. The number of bound charges contributed by polar molecules is generally much less than those contributed by non-polar molecules and atoms.

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 negative free 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

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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 and helps to lift light objects like wool, as shown in Figure 1.

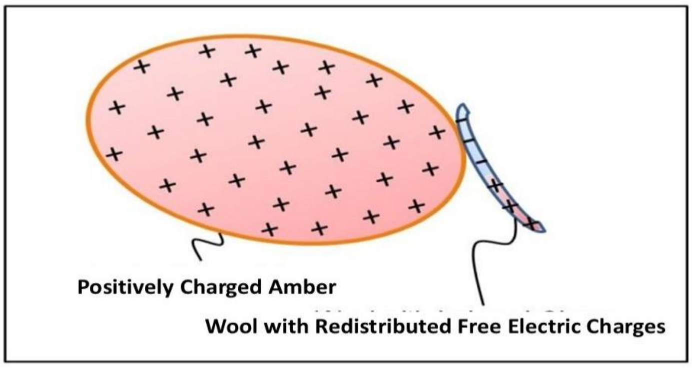

Figure 1. The positively "charged" amber picks up "uncharged" wool. The negative free charges and positive free charges are distributed in the blue and red regions in wool, respectively.

At the same time, under the influence of the positive electric field of the amber, the distribution center of induced negative net charges (from polarized polar and non-polar molecules and atoms) in the wool will be close to the amber, while the distribution center of all induced positive net charges (also from polarized polar and non-polar molecules and atoms) will be farther from the amber. This difference in location between the two charge distribution centers makes the amber's attractive force slightly larger than its repulsive force on the wool, also helping to pick up the wool. Thus, the total attractive force is sufficient to lift the wool.

It is important to emphasize that the polarized polar molecules, non-polar molecules, and atoms in the wool are the main contributors to the attraction between the amber and wool. The attractive force between the amber and wool is a synthetic electric force produced by a large number of electric charges, including both positive and negative charges, in both the amber and wool. Although the wool is small, it contains a large number of molecules and atoms, and thus a large number of free and induced net 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 repel negative free charges, causing the distribution center of induced negative net charges to be farther from the rod, and will attract the distribution center of induced positive net charges closer to 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 positive net or negative net charges, the uncharged wool will always be attracted to the charged object.

The author explained why a small uncharged piece of paper 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 Gravitational Force

From understanding that a "charged" object can attract an "uncharged" object to understanding origin of the gravitational force, that is, an attractive force can originate spontaneously between any two "uncharged" objects, the key step is to recognize that a directional non-uniform charge distribution with randomly orientation exists in any seemingly electrically neutral object.

Due to various macroscopic and microscopic causes, positive net and negative net charges will appear in almost any object, resulting in non-uniform electric charge distribution in almost any object. These causes include the movement of free electrons, thermal vibrations of polar and non-polar molecules and atoms, collisions among subatomic particles, varying densities of molecules and atoms, and differences in physical and chemical characteristics such as composition, state,

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temperature, pressure, fluidity, and conductivity. These myriad causes make the presence of non-uniform charge distribution in the object unavoidable and normal. The common belief that the electric charge distribution in an 'uncharged' object is always uniform is incorrect.

For example, Earth is a typical object with spontaneous non-uniform and unstable distributions of electric charge and electric field. The causes include various substance compositions with different physical and chemical properties in different regions, especially at different depths in Earth's interior. These non-uniform distributions are continuously changing. Measurements have indicated the presence of an electric field surrounding the Earth [9]. The field magnitude is about 100 volts per meter at ground level, and the field direction is downward. The surface of the Earth is negatively charged with many charge states [10]. It is also known that the Earth has a strong magnetic field. The Earth's magnetic field likely results from the continuous flow of a large number of net electric charges on its surface and within its interior.

In addition, astronomical observations and detections have shown that both the Moon and the Sun have their own electric fields. The Moon has an electric field near its surface, especially when it's full and passes through Earth's magnetotail, and the lunar nightside surface is negatively charged [11]. The Sun's electromagnetic fields are complex and constantly changing, mainly generated by the movements of charged particles (plasma) in its interior, and these electromagnetic fields are also influenced by the Sun's rotation and temperature [12].

Events occurring on the Earth, the Moon, and the Sun may also occur on other celestial bodies. Some events that occur in large objects like the Moon, the Earth, and the Sun may also occur in small objects. For example, the non-uniform distribution of electric charge can occur in small objects such as wool. For free electrons, polar molecules, non-polar molecules, and atoms, small objects like wool are sufficiently large.

To simplify the analysis of non-uniform charge distribution, total positive net charges are regarded as concentrated at a positive charge center, and total negative net charges are regarded as concentrated at a negative charge center, similar to the "mass center" used in mechanics.

In most macroscopic objects, even in massive celestial bodies like the Sun, the Earth, and the Moon, the distance between the two centers of positive and negative charges in their internal non-uniform charge distribution is extremely small. Calculations show that this distance, even in the Sun, the Earth, and the Moon, is within the range of 10^{-19} to 10^{-22} meters. Since the atomic nucleus diameter ranges from 2 to 15 femtometers (1 femtometer = 1×10^{-15} meters), this distance is smaller than the diameter of an atomic nucleus. Note that the distance between two charge centers is an abstract physical concept describing the synthetic property of non-uniform charge distribution formed by a large number of charged particles. It is not the real distance between any two actual charged particles, as even the distance between two electrons can be larger than 10^{-19} to 10^{-22} meters. Detailed definitions of the two charge centers will be provided below.

Because the distance between the two charge centers of a non-uniform charge distribution in most macroscopic objects is smaller than the diameter of an atomic nucleus, such a distance can easily occur due to various causes mentioned above and should be considered a normal occurrence. Thus, since the two charge centers cannot be located at the same point almost all the time, and in most objects, the quantities of positive and negative charges are almost equal, almost any object inherently becomes an electric dipole.

In the absence of an external electric field, the direction of an object's electric dipole is randomly oriented, resulting in an overall electrically neutral state for the whole object statistically. When an external electric field is applied to an object, it exerts a torsional force on the object's electric dipole. Due to the continuous action of the external electric field, the electric field strength between two objects will increase, resulting in a stronger and stronger attractive electric force between them. Thus, the attractive force between the two objects can start spontaneously and grow from weak to strong.

There is, of course, a limitation to the force strength of this electric interaction. With the continual movement of free electrons within each object, negative net charges will increase in some areas, while positive net charges will increase in others. The increase in the amounts of positive and negative net

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charges in different areas will enhance the repulsive forces against charges of the same sign entering these areas. Consequently, these increased repulsive forces will gradually reduce further movements of the free electrons in each object. Similar limitations apply to the induced net charges from polar 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 stabilize. In other words, the electric dipoles of the two objects will eventually align in the same direction.

In a uniform external electric field, an object's electric dipole experiences only a torque and no attractive or repulsive force. This occurs because the positive and negative charges at opposite ends of the dipole experience two equal but oppositely directed forces in a uniform external electric field, resulting in a net force of zero. An electric dipole experiences a net attractive or repulsive force only in a non-uniform electric field with a gradient strength distribution.

Under an external electric field, the directional non-uniform charge distribution changes. In the object, the free electrons move, the directions of polar molecules are re-oriented, and the directions of polarized non-polar molecules and atoms are re-oriented as well.

In these changes, only the free electrons actually move, forming a small electric current and generating weak magnetic fields, electromagnetic radiation, and noise. The positive ions are essentially immobile. For polar and non-polar molecules, their changes are only directional re-orientations, which involve slight displacements of atoms within the molecules. For atoms, which are the predominant components of most objects, their changes from non-polarized states to polarized states only involve changes in the orbital shapes of rotating electrons in atoms, from circular to elliptical, and these changes are generally small. Therefore, the re-orientation of object’s electric dipole under an external electric field does not generate significant electromagnetic radiation or energy dissipation. The following calculations will quantitatively demonstrate this.

Here, the author indicates again that the directional non-uniform charge distribution within the object is generated spontaneously. The role of an external electric field is to redistribute the directional non-uniform charge distribution, thus orienting the direction of the object’s electric dipole. Please note that, in most cases, because the distances between atoms and molecules within the object are very short, the strength of the internal electric field of an object is much larger than the strength of the external electric field.

Such an electrical attractive force can be produced between any two objects. These objects can range from as large as galaxies and galaxy clusters to as small as molecules and atoms because even atoms can become tiny electric dipoles when they are polarized to have separated positive and negative charge centers. Such electrical attractive force is just the gravitational force. It is the origin of the gravitational force.

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

Understanding how an attractive force can arise spontaneously between two seemingly electrically neutral objects may still be challenging. However, if a seemingly electrically neutral wool can be attracted by an electric field, why can’t another seemingly neutral object be attracted by an electric field? Additionally, if a “positively charged” amber or a “negatively charged” plastic rod can attract “uncharged” wool, why can’t the Earth, which has a downward electric field on its surface, 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. Therefore, similar to a charged amber attracting uncharged wool, the Earth, having an obvious electric field on its surface, will certainly attract a person on its ground. In the following section, the author will explain this further.

In reality, the spontaneous existence of directional non-uniform charge distribution with random orientations is common in seemingly electrically neutral objects. The misconception has long prevented people from discovering the true origin of gravitational force.

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The generation process of the electric attraction force between any two objects is not visibly observable because the orientation and re-orientation of the directional non-uniform charge distribution are caused by the movements of free electrons and the polarizations of polar molecules, non-polar molecules, and atoms. These movements and polarizations (shifts of charge centers of non-uniform distribution) occur at very high speeds, possibly close to the speed of light, and cannot be seen visibly. Therefore, because these processes can start spontaneously, grow, and finish instantly without being visible, the generation of gravitational force appears strange and mysterious.

In interactions involving a large number of positive and negative electric charges, most electrical attractive forces are canceled out by electrical repulsive forces due to the opposite signs of the electric charges, as shown in Figure 2.

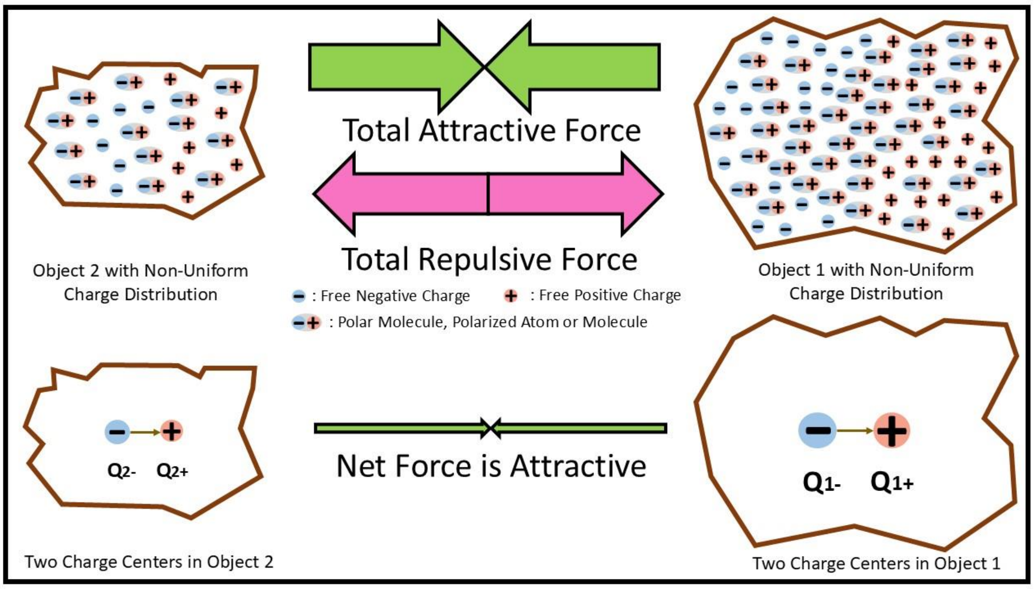

Figure 2. The electric interaction force between two objects with directional non-uniform charge distributions. The total positive net charges and total negative net charges in each object are regarded as concentrated in their charge centers, represented by orange and blue circles with charge amounts q_{1+}, q_{1-}, q_{2+} and q_{2-}, respectively.

In most cases, the external electric field produced by an object is unevenly distributed in space, meaning that the strength of the external electric field has a gradient. As a result, the external field forces acting on the positive and negative charges within another object will have a slight deviation, leading to a weak net electric interaction force.

Although gravitational force and electric force both have extremely long interaction distances and extremely fast interaction times, the strength of gravitational force is much smaller than that of electric force. In fact, gravitational force is about 36 to 40 orders of magnitude weaker than electric force. This significant difference in strength is a key reason why gravitational force is not considered to be an electric force.

Calculation of Gravitational Force

In an object, the non-uniform charge distribution may be very complicated, making the analysis and calculation of the produced electric field difficult. To simplify this, two net electric "charge centers," similar to the "mass center" used in mechanics, are defined. Regardless of the complexity of the positive net and negative net charge distributions, all electric forces generated by all positive net charges can be synthesized into a single positive electric force. The point from which this synthetic electric force is exerted on another object is the positive net electric "charge center." Similarly, the net negative electric "charge center" is defined. With this simplification, any object with a directional non-uniform distribution can be regarded as having a "positive net charge center" and a "negative net charge center." All positive net charges are considered concentrated at the "positive charge center," and all negative net charges are considered concentrated at the "negative charge center." As emphasized above, because these two charge centers are almost never at the same point for almost any object, and the two kinds of electric charges have equal or almost equal amounts in any object, nearly any object with a directional 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 electric charge q. A small distance $\vec{\boldsymbol{l}}$ is between the two point charges. The electric dipole moment $\vec{\boldsymbol{p}}$ is the product of the distance $\vec{\boldsymbol{l}}$ and the charge q.

$$\vec{\boldsymbol{p}} = q\vec{\boldsymbol{l}}, \tag{1}$$

where $\vec{\boldsymbol{P}}$ and $\vec{\boldsymbol{l}}$ are vectors. The direction of the dipole moment $\vec{\boldsymbol{P}}$ is from the negative point charge to the positive point charge. The electrical field strength $\vec{\boldsymbol{E}}$ of the electric dipole at the distance of R is [13]

$$\vec{\boldsymbol{E}} = \frac{1}{4\pi\epsilon_0 R^3}\left[3\left(\vec{\boldsymbol{P}}\cdot\vec{\boldsymbol{R}}\right)\vec{\boldsymbol{R}} - \vec{\boldsymbol{P}}\right]. \tag{2}$$

In Eq. (2), $\vec{\boldsymbol{R}}$ is unit distance vector along the R direction. ϵ_0 is the electric constant. Note that, in deduction of Eq. (2), the terms in l^2 and higher order terms are neglected. This approximation is justified if $l/R \to 0$ keeping the product $P = ql$ finite [14], where l, R and P are absolute values of the vectors $\vec{\boldsymbol{l}}$, $\vec{\boldsymbol{R}}$ and $\vec{\boldsymbol{p}}$**.** This approximation is used for calculating the gravitational force easily.

Sometimes, the distance l between the "positive charge center" and "negative charge center" 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 because $R \gg l$. Thus, the distance between the positive and negative "charge centers" in the object may be treated as enough small, and such objects with directional non-uniform charge distributions may be reasonably regarded as electric dipoles.

From Eq. (2), we know that when the direction of the vector $\vec{\boldsymbol{R}}$ changes, the electric field strength $\vec{\boldsymbol{E}}$ changes too. When the direction of $\vec{\boldsymbol{P}}$ is the same as or opposite to the direction of $\vec{\boldsymbol{R}}$, the electric field strength $\vec{\boldsymbol{E}}$ becomes E_S or E_O

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

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

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

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

The E_P is negative. Please note that E_P is a deflective force.

Thus, a problem arises: if the electric field strength of an object with a directional non-uniform charge distribution is not isotropic, why have we not observed that the gravitational force between two objects varies with their relative direction? 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 change to attractive forces. This occurs because when the interaction between two electric dipoles is repulsive, both dipoles are in states of highest electric potential energy, which is unstable. Any change in the charge distribution of one object will produce a deflective force between the two dipoles. This deflective force will rotate the dipoles, eventually making the force between them attractive.

The process by which repulsive and deflective forces become attractive forces, that is, the rotations of electric dipole moments, can occur automatically and continuously. This is a continuous self-calibrating process due to the mutual influence of the electric fields of two electric dipoles. The change in direction of the electric dipole only requires the redistribution of the directional non-uniform charge within the object and doesn't require the rotation of the macroscopic object. Since the movements of free electrons and the rotations of polarization directions of polarized molecules and atoms have very high speeds and are not visible, this process can be completed almost instantly and can be dynamically continued. Consequently, the interaction force between two objects may always appear to be attractive, whether they rotate around each other or not, resulting in a seemingly isotropic gravitational force between them.

Of course, 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 comets have strange trajectories. More explanations will be given below.

Therefore, any two macroscopic objects can be regarded as two electric dipoles. When these two electric dipoles are aligned in the same direction along a line, they will attract each other, as shown in Figure 3.

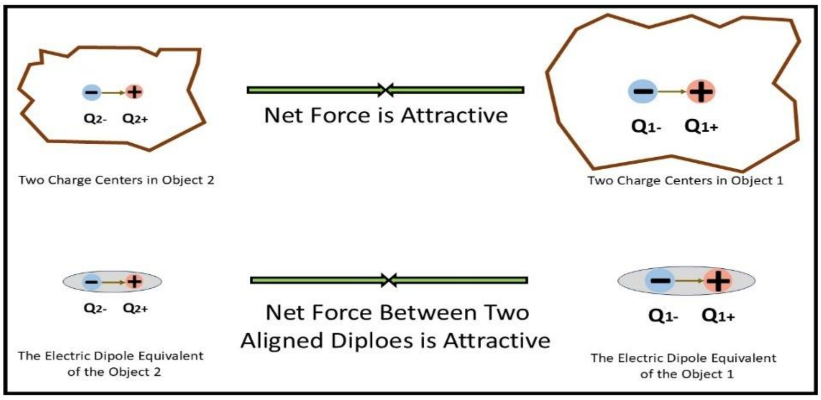

Figure 3. Two macroscopic objects that attract each other, like two electric dipoles attracting each other.

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 4, 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.

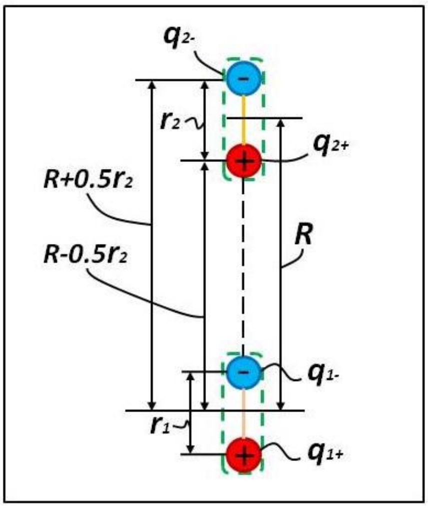

Figure 4. Interaction forces between two electric dipoles when dipole moment directions are the same.

From Eq. (2), the first electric dipole will produce the electrical field $\vec{E}_1$ at the distance R from its center

$$\vec{\boldsymbol{E}}_{\boldsymbol{1}} = \frac{1}{4\pi\varepsilon_0 R^3}\left[3\left(\vec{\boldsymbol{P}}_{\boldsymbol{1}} \cdot \vec{\boldsymbol{R}}\right)\vec{\boldsymbol{R}} - \vec{\boldsymbol{P}}_{\boldsymbol{1}}\right]. \tag{6}$$

In the electrical field $\vec{\boldsymbol{E}}_{\boldsymbol{1}}$, the positive point charge q_{2+} of the second dipole will feel a force $\vec{\boldsymbol{F}}_{\boldsymbol{q2+}}$ as

$$\vec{\boldsymbol{F}}_{\boldsymbol{q2+}} = q_{2+}\,\vec{\boldsymbol{E}}_{\boldsymbol{1}} = \frac{2q_{2+}\vec{\boldsymbol{P}}_{\boldsymbol{1}}}{4\pi\varepsilon_0(R-0.5r_2)^3}. \tag{7}$$

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

$$\vec{\boldsymbol{F}}_{\boldsymbol{q2-}} = q_{2-}\,\vec{\boldsymbol{E}}_{\boldsymbol{1}} = \frac{2q_{2-}\vec{\boldsymbol{P}}_{\boldsymbol{1}}}{4\pi\varepsilon_0(R+0.5r_2)^3}. \tag{8}$$

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

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 $\vec{\boldsymbol{E}}_{\boldsymbol{1}}$ is $\vec{\boldsymbol{F}}_{\boldsymbol{D}}$ approximately

$$\vec{\boldsymbol{F}}_{\boldsymbol{D}} = \vec{\boldsymbol{F}}_{\boldsymbol{q2+}} + \vec{\boldsymbol{F}}_{\boldsymbol{q2-}} \doteq \frac{6r_1r_2}{R^2}\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{R^2}\vec{\boldsymbol{R}}. \tag{9}$$

In Eq. (9), if $\sqrt{6}r_1q_1$ is replaced by m_1, $\sqrt{6}r_2q_2$ is replaced by m_2, and $\frac{1}{4\pi\varepsilon_0}$ is replaced by a constant G', then Eq. (9) becomes

$$\vec{\boldsymbol{F}}_{\boldsymbol{D}} = G'\frac{m_1m_2}{R^4}\vec{\boldsymbol{R}}. \tag{10}$$

Please note that the dimension in SI unit of the constant G' is Nm^2C^{-2} (Newton-meter squared per Coulomb squared). It is different from Nm^2kg^{-2} (Newton-meter squared per kilogram squared) of the gravitational constant G in Newton's formula.

We can see that Eq. (10) is very similar to Newton's gravitational law except the difference between $\frac{1}{R^4}$ and $\frac{1}{R^2}$.

$$\vec{\boldsymbol{F}}_{\boldsymbol{G}} = G\frac{M_1M_2}{R^2}\vec{\boldsymbol{R}}. \tag{11}$$

Eqs. (9) and (10) show that the physical essence of the mysterious mass is the amount of electric charge. More strictly speaking, the mass is another expression of the amount of the electric charge multiplied by the length of the related electric dipole.

Compare Newton's law of the gravitational force $\vec{\boldsymbol{F}}_{\boldsymbol{G}}$ with Coulomb's law of the electric force $\vec{\boldsymbol{F}}_{\boldsymbol{E}}$

$$\vec{\boldsymbol{F}}_{\boldsymbol{E}} = K\frac{q_1q_2}{R^2}\vec{\boldsymbol{R}}. \tag{12}$$

We can see that their expressions are very similar. Eq. (11) express the attractive gravitational forces 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-like electric charges of q_1 and q_2. G' or G is gravitational constant. K is Coulomb's constant. Their numerical values depend on the system of the units used. If two charges in Eq. (12) are replaced by two masses in Eq. (11), then Eq. (12) becomes Eq. (11), and both G and K have the same numerical value and dimension. Thus, we profoundly see the physical rationality of the understanding that gravitational force is originated from the electric force.

The striking similarity between Eq. (11) and Eq. (12) strongly suggests that the gravitational force is the electric force. If two physical forces are fundamentally different, their mathematical expressions should differ significantly. However, where else can we find such a similarity between the expressions of two distinct physical forces?

When two dipole moments are opposite, the interaction forces between them become repulsive, as both dipoles are pushed by repulsive electric fields, as described by Eq. (3). However, as explained above, in most cases, two interacting electric dipoles cannot push each other for long. When an electric dipole is influenced by a deflective force, even a small one, its dipole moment will rotate and eventually align with the force's direction.

As mentioned above, the rotation of the electric dipole doesn't require the rotation of the real physical body of the object. It only needs a change in the distribution of net electric charges, including free and induced net charges in the object. Such changes are easy, very fast and cannot be seen visibly. This phenomenon explains why the gravitational force is always attractive.

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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 two objects, can be expressed by Eq. (9) or (10) only.

Figure 5 shows that the two electric dipoles, representing the two macroscopic objects, always attract each other, even if one rotates around the other.

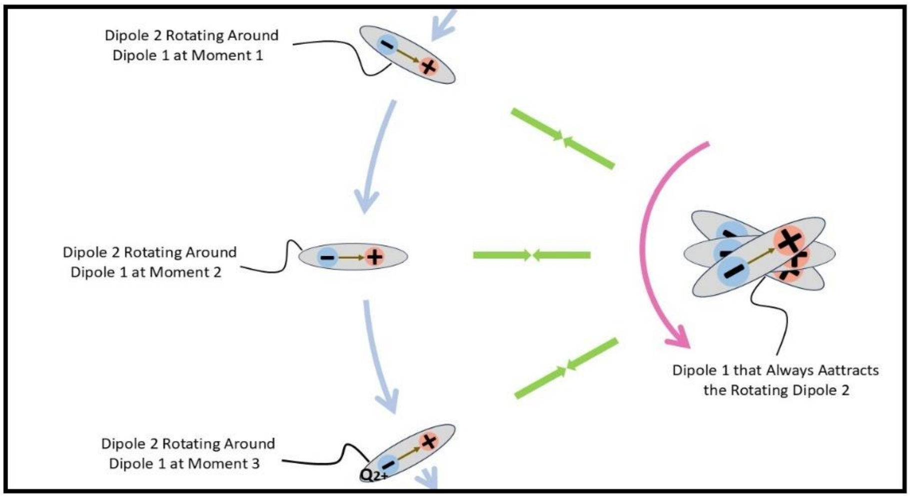

Figure 5. The two electric dipoles, representing the two macroscopic objects, attract each other when one rotates around the other.

When three objects interact, the free and induced net charges in each object are redistributed in response to the external 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 two objects. Thus, the redistribution of charges in each object can be regarded as forming two electric dipoles. Each dipole in one object responds to an external dipole in one of the other two objects, leading to the analysis of interactions among six electric dipoles. When more objects are involved, the analysis of gravitational forces becomes more complex. However, the redistribution of net charges in each object can still be regarded as forming multiple electric dipoles, each responding to a dipole in each of the other objects.

The dynamically self-calibrating process may apply to multiple electric dipoles, or even multiple groups of electric dipoles, causing them to mutually and continuously attract each other, whether they rotate around each other or not. The attractions between multiple electric dipoles, or even multiple groups of electric dipoles, can be understood in this way: the multiple electric dipoles or groups of electric dipoles may form a larger combined charge distribution. As long as this larger combined charge distribution is directionally non-uniform, it will act as a combined electric dipole. Thus, any other electric dipole will be attracted to this combined electric dipole. The other electric dipole may consist of a single electric dipole, multiple electric dipoles, or multiple groups of electric dipoles. Therefore, based on the introduced electric dipole model theory, multiple electric dipoles, or even multiple groups of electric dipoles, can continuously attract each other.

Eq. (9) or (10) expresses the interactional electric force between two electric dipoles when the dipoles are aligned in the same direction. This electric force is the gravitational force between two objects. According to Eq. (9) or (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 essentially an electric field.

Second, the strength of the gravitational force depends on the direction of the electric dipole, meaning that the gravitational force is essentially anisotropic. However, due to a dynamically self-calibrating process, a constant and seemingly isotropic attraction can be maintained between two objects, whether they rotate around each other or not. Thus, although at any given moment the gravitational force is anisotropic, after successive and numerous micro self-calibrations at very high speed, the overall performance of the gravitational force appears to have an isotropic attraction capacity.

Third, comparing $\sqrt{6}r_1q_1$ with m_1 and $\sqrt{6}r_2q_2$ with m_2 in Eq. (9) or (10), since the most of the attractive force between two objects is canceled out by the repulsive force between two objects, the gravitational force strength caused by m_1 or m_2 is much smaller than the electric force strength caused by q_1 or 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. (9) are not fixed because they are determined by the charge distributions in two objects. Since variations of charge distributions 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.

The strength of the electric force shown by Eq. (9) or (10) is inversely proportional to the fourth power of the distance R from the dipole. This is in serious contradiction with Newton's laws. This problem is a key challenge of the electric dipole model theory of gravitational force. The author has attempted to solve this problem using a new physical mechanism. This mechanism is based on the idea that macroscopic objects are not ideal electric dipoles, and the polarization of macroscopic objects under an external electric field is not linear. Calculations based on this new mechanism have indeed shown that, under certain conditions, the strength of the electric force between two macroscopic objects can be closely inversely proportional to the square of the distance R from the object. This is highly consistent with the results of precise measurements by modern technology. In the following, detailed calculations and explanations will be provided.

Eq. (9) or (10) states that the gravitational force strength between two objects depends on their net electric charges and electric dipole moment lengths. Thus, the gravitational force between two objects seems to be easily variable. However, according to our usual understanding, the gravitational force between two objects is considered invariant as their masses are constant.

This understanding has limitations. The reason is that we typically observe the gravitational force between objects, or the weight of objects, only on or near the Earth's surface. In this context, the electric charge distribution within the object is mainly determined by the physical structure and states of all atoms and molecules within the object, as well as the influence of the Earth's electric field on it. Since, on the Earth's surface, the change in the overall strength of the Earth's electric field acting on the object is minimal, and the physical structure and states of all atoms and molecules within an object also undergo no large changes, the so-called mass of an object, or the weight of an object, can be considered constant.

Characteristics of Gravitational Force

1. Equivalence Principle of Gravitational and Inertial Mass

What is mass? This question has not been clearly answered. In physics, the concept of mass has two meanings: gravitational mass and inertial mass. Based on the new understanding of gravitational force, an object's gravitational mass represents the strength of the attractive force exerted on the object by the synthetic electric field of the Earth's total electric charges when the object is motionless relative to the Earth. The object's inertial mass represents the strength of the attractive force exerted on the object by the synthetic electric field of the total electric charges distributed in the space through which the object is moving. On or near the Earth, whether an object is in motion or motionless, the synthetic electric field exerted on that object is almost entirely generated by the Earth's total electric charge. As a result, the gravitational mass and inertial mass of an object are always equal.

Here, the author addresses the well-known problem of why the gravitational mass and inertial mass of an object are always equal. Therefore, the newly introduced understanding of gravitational force can not only establish the equivalence principle but also provide a substantive reason for its establishment.

This new understanding of gravitational force also provides the real physical explanation for Einstein's mass-energy conservation law, $E = mC^2$. Since both the gravitational mass and the inertial

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mass of an object are expressions of the interaction force strengths exerted on it, the change in motion energy of an object caused by an external force will naturally cause the so-called mass of that object to change. In other words, the real physical meaning of Einstein's mass-energy conservation law is that it expresses the transformation relationship between the gravitational force exerted by Earth on an object and the action force (or ability) of that object on another object.

2. Fre-Fall Law for Different Objects

In the above derivation, it is concluded that the mass of a macroscopic object is determined by the product of the charge amount of the object and the dipole moment length of the object. Thus, mass is no longer an invariant quantity but is related to factors such as the material, structure, shape, and so on. As classical physics laws consider mass to be an invariant quantity, does the electric dipole model of gravitational force violate the free-fall law?

Such concerns are unnecessary. In a vacuum, the electric dipole model theory of gravitational force can still derive that different kinds of objects have the same gravitational acceleration in the same gravitational field, regardless of their material, structure, shape, weight, and so on.

According to the above Eq. (9), let the mass of the Earth be m_1, then $m_1 = \sqrt{6}r_1q_1$. If the mass of an object on the Earth's surface is m_2, then $m_2 = \sqrt{6}r_2q_2$. Thus, the gravitational force between the object and the Earth may be expressed by Eq. (9).

When the object falls with an acceleration, $\vec{\boldsymbol{a}}$, on the surface of the Earth, there is

$$\vec{\boldsymbol{F}}_D \doteq m_2\vec{\boldsymbol{a}} = \vec{\boldsymbol{a}}\sqrt{6}r_2q_2. \tag{13}$$

Comparing Eq. (9) and Eq. (13), we have

$$\vec{\boldsymbol{a}} \doteq \frac{1}{4\pi\varepsilon_0}\frac{\sqrt{6}r_1q_1}{R^4}\vec{\boldsymbol{R}}. \tag{14}$$

The observable acceleration of a falling object, $\vec{\boldsymbol{a}}$, is only related to the properties of Earth and is independent of the object's properties. This means that different objects, regardless of their material, structure, shape, weight, and so on, have the same falling acceleration on the Earth's surface.

Of course, according to the dipole model of gravitational force, the falling acceleration of the object is inversely proportional to the fourth power of distance R, which violates Newtonian law. In the following, the author will discuss the change rate of gravitational force strength with distance further and solve this problem.

Thus, large and small metal balls with different so-called masses could fall at the same speed from the Leaning Tower of Pisa, as demonstrated by Galileo. For a similar reason, in the absence of air resistance, a feather and a metal block may fall simultaneously on the lunar surface, as demonstrated by a U.S. astronaut in 1971.

3. Extremely Weak Strength and Extremely Long Interaction Distance of Gravitational force

There is an electric field of about $E_e = 100$ volts per meter on the Earth's surface. If gravitational force were an electric force, could the electric field strength at Earth's surface hold objects on its surface? Take each of us, for example. The real fact is, the Earth's surface electric field can not only hold objects at its surface but is also potent enough to destroy any object on the Earth's surface, unless each object is treated as an electric dipole. The author will now provide calculations to prove this.

This issue actually relates to the fact that gravitational force is extremely weak compared to electric force.

One extremely peculiar characteristic of gravitational force is its extremely weak strength, being 10^{36} to 10^{40} times weaker than that of the electric force, yet its interaction distance is very far. Countless celestial bodies, even those located in distant deep space, are affected and controlled by this extremely faint force. For a long time, this has been one of the most profound mysteries of the universe.

However, the electric dipoles model theory of gravitation can explain this mystery effectively and satisfactorily. As described above, gravitational force is essentially a synthetic electric force produced by a large number of electric charges, including both positive and negative charges. When two objects interact, one object's dipole electric field acts on both the positive and negative charges

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within another object simultaneously. Thus, the attractive force on positive charges will be canceled by the repulsive force on negative charges. If the external electric field is uniform, an object's electric dipole experiences two equal but oppositely directed forces, resulting in a net force of zero. An electric dipole experiences a net attractive or repulsive force only in a non-uniform electric field with a gradient strength distribution.

Taking the human body as an example to further describe the influence of the Earth's electric field:

The strength of Earth's surface electric field is about $E_e = 100$ volts per meter. If a person's body mass is $m_m = 100$ kilograms, and considering the mass of a proton is $m_p = 1.67 \times 10^{-27}$ kilograms, there are approximately $\frac{m_m}{m_p} \approx 5.99 \times 10^{28}$ electrons in the person's body. Here, we assume that each atom in the human body consists only of electrons and protons.

As the charge of an electron is $q_e = 1.6 \times 10^{-19}$ coulombs, the electric force exerted by the Earth's electric field on each electron is $F_e = E_e q_e = 1.6 \times 10^{-17}$ newtons. Thus, if the Earth's electric field entered the person's body without any attenuation (though in reality, the skin effect reduces the penetration field strength, as explained further below), the total electric attractive or repulsive force on all electrons or nuclei in that person's body would be $F_{Te} = E_e \frac{m_m}{m_p} q_e$ =9.58× 10^{11} newtons.

Such a large force would theoretically split the body instantly. If we consider that the protons and neutrons in each atom in the person's body consist of photon electric dipoles (see detailed descriptions below), the total electric attractive or repulsive force F_{Te} would increase by two to three orders of magnitude. The Earth's electric field would split that person's body even faster.

However, it is known that the actual gravitational force exerted by the Earth on a 100-kilogram person is only 980 newtons, which is much less than the value estimated above, by a factor of about 10^9. This is because the gradient of the electric field at the Earth's surface is very small, and thanks to the protection provided by the skin effect on the human body, the net and effective force exerted by the Earth's surface electric field on the human body is suitably small.

Please also note that the Earth's electric field force acts dispersedly on the charges in a vast number of atoms within the body. In each of these atoms, the positive and negative charges are very close to each other, and their mutual attraction is very large, maintaining the stability of the atom. Thus, the Earth's gravitational (electric) force cannot split each atom, and therefore cannot split the person's body.

Because gravitational force is essentially electric force, and the interaction distance of electric force is theoretically unlimited. Although the strength of an electric dipole's electric force is inversely proportional to the cube of the distance, theoretically, even at extremely great distances, the strength of an electric dipole's electric force will never be absolutely zero.

4. Skin Effect of Electric Field on Object

For a closed metal container, such as a Faraday Cage, the charges on the container's surface redistribute under the influence of an external electric field. This redistribution produces an induced electric field opposite to the external field, making the internal electric field in the container nearly zero. This phenomenon is known as electrostatic equilibrium in conductors. Such containers can effectively shield the internal area from external electric fields, protecting it from electrical interference.

This raises a question: the dipole model theory of gravitational force regards the gravitational field as the electric field. This leads to the hypothesis that if an object is placed inside a closed metal container, the Earth's gravitational field, being an electric field, would be shielded by the container, causing the object inside to lose the Earth's gravitational pull and effectively lose its weight. Clearly, this situation has not been observed. How can the weight of object inside a closed metal container be explained?"

Indeed, this issue poses a challenge to the dipole model theory of gravitational force. After analysis and investigation, the author has gained new insights into the process and complexity of the interaction between gravitational force and object. Based on this new understanding, the author finds

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that this issue is actually a paradox that seems plausible but is not, and the dipole model theory of gravitational force can still firmly stand. An explanation is provided in conjunction with Figure 6.

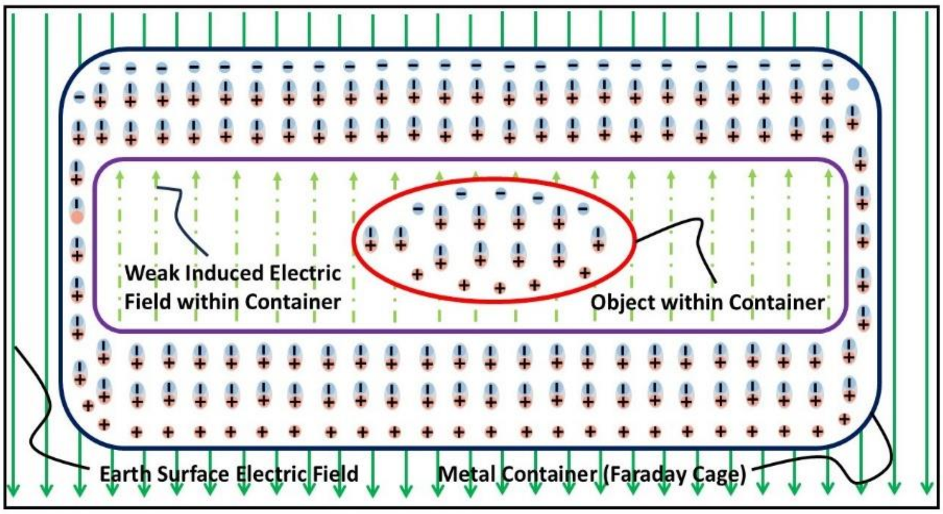

Figure 6. An object is inside a closed metal container, and the external electric field causes a skin effect on the container's surface.

In Figure 6, a closed metal container is located on the Earth's surface. An electric field exists on the Earth's surface, directed from the sky to the ground. Under the influence of this electric field, free electrons on the container's surface quickly move to the upper surface, while the lower surface, lacking free electrons, will have a nearly equal number of positive charges. This redistribution of electrons forms an induced electric field, which is approximately equal in strength and opposite in direction to the Earth's electric field. As a result, the Earth's electric field outside the container and the induced electric field almost cancel each other out, making the electric field strength inside the container approximately zero. It is important to note that the electric field strength inside the container is approximately zero, not absolutely zero.

No Faraday cage can completely shield an external electric field. The effectiveness of a Faraday cage depends on the frequency of the external electromagnetic wave. To block electromagnetic waves with lower frequencies, a thicker Faraday cage is required; to block higher frequencies, a cage with smaller holes is needed. The Earth's electric field has a very low frequency, so any practically feasible thickness of a closed metal container cannot completely shield external field, and a small portion of the Earth’s electric field will always penetrate the container.

In Figure 6, under the influence of the downward Earth's electric field (as the Earth's surface is negatively charged), the free electrons on the lower surface of the container are driven to the upper surface, forming a negatively charged layer there. The atom layer closest to this negatively charged surface will be polarized, forming the topmost polarized atom layer. This polarization will induce further polarization in adjacent atom layers, extending to the upper wall of the container's interior. Meanwhile, the positive ions on the lower surface of the container, lacking free electrons, form a positively charged layer, inducing polarization in the adjacent atom layers and extending to the lower wall of the container's interior. All atom layers are polarized downward.

Thus, the electron and ion layers with opposite polarity appearing on the upper and lower surfaces of the container will generate an induced electric field. Since the direction of the induced electric field is opposite to that of the external electric field, it greatly weakens the strength of the external electric field, meaning the net electric field strength inside the container is weak. This weak electric field will act on the object inside the container.

This is the skin effect produced by the external electric field on the surface of the conductor. We see that this skin effect has the following characteristics:

1. The induced electric field greatly weakens the strength of the external electric field, making the electric field strength inside the container very weak.
2. The attenuation of the electric field strength occurs mainly within a thin surface layer of the container.
3. The stronger the external electric field, the stronger the skin effect it causes, resulting in the electric field strength inside the container always being weak, regardless of the strength of the external electric field.
4. The strength of the external electric field decays non-linearly (usually at an exponential rate) within the thin surface layer of the container, and thus, the electric field strength inside the container does not change linearly with the strength of the external electric field generally.

Although the electric field inside the container is weak, it can still exert sufficient attraction on the object inside the container. This is because the force exerted by the electric field on the object is determined by both the strength of the electric field and the number of charges within the object, according to Coulomb's law.

$$F_I = E_I q_I. \tag{15}$$

Where E_I is the strength of the electric field inside the container, q_I is the absolute value of total positive or negative charges of object in the container, and F_I is Coulomb force produced by electric field on the object in the container. Therefore, although E_I is weak, if q_I is large, F_I may be still sufficiently large. Generally, a common object contains a large number of charges, so even a weak electric field can produce a sufficiently large gravitational force.

In fact, it is precisely because the skin effect and the aforementioned external electric field simultaneously act on the positive and negative charges within the object, the Earth's electric force is reduced significantly for the object within the container. Otherwise, that object would be damaged.

The system composed of a metal container and an enclosed object is a specific example. Any object in nature can be viewed as a similar system, consisting of an outer shell and the material enclosed by that shell. In the example above, the system's outer shell is a metal conductor, and the inside material is an object. In more general cases, the outer shells of most objects are made of dielectric materials.

We know that dielectric materials in an electrostatic field will also produce induced charges externally. These induced charges create an induced electric field opposite to the direction of the external electric field, thereby weakening the net electric field strength inside the dielectric material. Although the electric field strength inside the dielectric material is smaller, sometimes much smaller, than the external electric field, it is not zero.

The attenuation of the external electric field penetrating the dielectric material is determined by the material's dielectric constant (relative permittivity), conductivity, and the frequency of the external electric field. Generally, the higher the frequency of the external electric field, the weaker the penetration field strength. This is described by the "penetration depth" of the electric field into the dielectric material. The "penetration depth" of a dielectric material is defined as the depth at which the electromagnetic field strength decays to about 37% of its surface value. Table 1 shows the "penetration depth" values of electric fields for common dielectric materials.

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Table 1. Typical penetration depths for various common materials and Frequencies.

Material	Frequency	Typical Penetration Depth (approx.)
Water (25°C)	2.45 GHz (Microwave frequences)	1–4 cm
Human Tissue	2.45 GHz	~2–4 cm
Wet Soil	Microwave Frequencies	Decimeters (shallower than dry soil)
Wood	2.54 GHz	8–350 cm (varies with moisture)
Copper	60 Hz	~8.5 mm
Industrial Dielectrics		5 cm to 10 cm

The penetration depth of general conductive materials, such as metals, is shallow, while that of insulating materials, such as wood, is deep. The moisture content of a material greatly affects its penetration depth. Since the human body contains a large amount of water, the penetration depth in the human body is relatively shallow, which is one reason why the human body is susceptible to electric shock.

Therefore, any object can be considered to have a shell. Different shells have different "effective penetration" thicknesses. These shells can produce a skin effect, weakening the electric field strength entering the object.

This realization leads the author to understand that the outer skin and shallow tissue layer of the human body not only block harm from outside bacteria and pollutants to internal tissues but also block external electric fields, especially strong external electric fields, from interfering with internal tissues. This allows the physiological activities within the body to proceed safely, including the normal transmission of signals such as vision and touch within the nerves, normal cell division, and even the normal transport of oxygen and nutrients, and so on.

Through further inference, we may understand another reason why various life forms need water. It is because water helps form an electrical protective layer on the surface of each living organism, preventing strong external electric fields from interfering with and damaging the normal life processes within these organisms.

Due to the skin effect, and the fact that the stronger the external electric field, the stronger the skin effect, a strong electric field is only effective over a relatively thin surface layer of the dielectric object. Thus, only a weak electric field can send electric energy with a higher ratio into the dielectric material.

Therefore, although the skin effect significantly weakens the electric field entering any object, any object can still be attracted by the Earth. This is also one of the reasons why various electromagnetic theories of gravitational force have been easily refuted over the years.

5. Strength Change Rate of Gravitational Force with Distance

In Newton's law, the strength of gravitational force is inversely proportional to the square of the distance, as confirmed by countless precise measurements. However, in the electric dipole model theory of gravitational force, the strength is inversely proportional to the fourth power of the distance as shown in Eq. (9) or Eq. (10), which presents the biggest challenge for this theory.

However, based on the contents given above and what will be described below, the electric dipole model theory can effectively explain various mysterious physical characteristics and puzzling astronomical phenomena about gravitational force. This is not a coincidence; it strongly supports the validity of the electric dipole model theory of gravitational force.

The contradiction between the electric dipole model theory and Newton's gravity theory suggests that there must be a physical mechanism that causes the electric attraction strength between

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two electric dipoles formed by macroscopic objects to be inversely proportional to the square of the distance between them. Identifying this mechanism is crucial to fully developing the gravitational electric dipole model theory. There is optimism in finding this mechanism because a macroscopic object cannot be equated to an ideal electric dipole. The distribution of positive and negative net charges within a macroscopic object is influenced by various factors, differing from the behavior of an ideal electric dipole under a simple external electric field.

Two potential physical mechanisms are considered. The first relates to the polarizability of the macroscopic object. The second involves the properties and influence of the object's surface, similar to boundary conditions in mathematical analysis, such as the skin effect (see described above).

Here, only the first mechanism is considered. Generally, it is believed that the polarizability of a macroscopic object depends on the strength of the external electric field and the properties of the object, such as its composition and structure. However, we must further recognize polarizability.

The polarizability of a macroscopic object describes its sensitivity to changes in charge distribution when exposed to an external electric field. In the universe, any independent object or substance system is composed of atoms and molecules, or electrons and ions. Within such an object or system, due to various macroscopic and microscopic reasons, the distribution of electric charges is always randomly oriented directional non-uniform, meaning there is inherent disorder. Because the distances between the atoms and molecules, or electrons and ions, are very short, the strengths of the interaction electric fields among them are very strong, much larger than that of the external electric field generally. Thus, the main effect of the external electric field is not to increase the object's or system's internal disorder but to regularize it, making the internal randomly oriented directional non-uniform charge distribution more oriented.

This physical mechanism can be further explained. In the universe, within a completely isolated object or substance system, the absence of external constraints leads to a state of extreme internal charge disorder. Although this extreme disorder usually results in statistical electrical neutrality, not a large electric dipole moment, the disordered charge distribution is highly sensitive to an external electric field. This means the external field can cause the isolated object or system to form an oriented electric dipole more easily. The degree of independence of an object or system is determined by its distance from another object or system. Therefore, the polarizability of a macroscopic object is related not only to the property and the field strength of another object but also to the distance from that object.

The interaction between two objects is essentially a process of energy transformation. According to the principle of energy conservation, the total energy of a force emitted from a point should be the same on different spherical surfaces at varying distances from that center point, similar to the energy spread of a Coulomb force emitted from a point charge. Since the surface area of a sphere is proportional to the square of its radius, the interaction force strength between two macroscopic objects should change with the square of the distance between them.

Let the dipole moment of the object 1 be $\vec{p}_1$, then under the electric field $\vec{E}_2$ of the dipole moment of the object 2, the $\vec{p}_1$ becomes

$$\vec{p}_1 = \vec{p}_{1\infty} + \alpha \vec{E}_2. \tag{16}$$

In Eq. (16), $\vec{p}_{1\infty}$ is the value of $\vec{p}_1$ when electric field $\vec{E}_2 = 0$. Because only when the distance R between two objects approaches infinity ($R \Rightarrow \infty$), the value of $\vec{E}_2$ can be zero, $\vec{p}_{1\infty}$ is also the value of $\vec{p}_1$ when the distance R approaches infinite. α (SI units: Cm^2/V coulomb-meter squared per volt squared) is polarizability of the object 1. When $\vec{p}_1$ and $\vec{p}_2$ have the same direction and are aligned with a line, from Eqs. (3) and (16), we have

$$p_1 = p_{1\infty} + \alpha E_2 = p_{1\infty} + \frac{\alpha p_2}{2\pi\varepsilon_0 R^3}. \tag{17}$$

If the physical properties and external environments of the two objects are not significantly different, then $p_2 \approx \gamma p_1$, where γ is a dimensionless proportional constant. Thus, from Eq. (17), a self-consistent equation for calculating p_1 can be obtained

$$p_1 = p_{1\infty} \frac{2\pi\varepsilon_0 R^3}{2\pi\varepsilon_0 R^3 - \alpha\gamma}. \tag{18}$$

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Defining equivalent masses of object 1 and object 2 as $m_{E1} = \frac{\sqrt{6}p_1}{R}$ and $m_{E2} = \frac{\sqrt{6}p_2}{R}$. As $P_1 = r_1 q_1$ and $P_2 = r_2 q_2$, Eq. (9) becomes

$$\vec{F}_D \doteq \frac{1}{4\pi\varepsilon_0}\frac{m_{E1}m_{E2}}{R^2}\vec{R}. \quad (19)$$

Please note that if let $m_{E1} = M_1$, $m_{E2} = M_2$ and $G = \frac{1}{4\pi\varepsilon_0}$, then, Eq. (19) becomes Eq. (11) of Newton's gravity law.

From Eq. (18) and $m_{E1} = \frac{\sqrt{6}p_1}{R}$, we have

$$m_{E1} = \sqrt{6}\, p_{1\infty}\frac{2\pi\varepsilon_0 R^2}{2\pi\varepsilon_0 R^3 - \alpha\gamma}. \quad (20)$$

When $R^3 = \frac{\alpha\gamma}{2\pi\varepsilon_0}$, $p_1 = \infty$, $m_{E1} = \infty$, Eqs. (18) and (20) encounter singularities. At singularities, the physical approximation on which the Eqs. (18) and (20) are based fails, resulting in the Eqs. (18) and (20) becoming invalid. Additionally, Eq. (20) shows when $R \Rightarrow \infty$, $m_{E1} \Rightarrow 0$. This is because, based on the dipole model, both the gravitational mass and inertial mass of an object represent the strength of the attraction force experienced by another object (see above descriptions). If an object is located at infinity, the attraction force exerting on another object by that object is zero, and thus its equivalent mass m_{E1} (and so the so-called mass m_1) becomes zero.

However, although the equivalent mass (and thus the so-called mass) of the object becomes zero, the object itself does not disappear. According to the electric dipole model theory, the equivalent mass (and thus the so-called mass) of an object is no longer an inherent and unchanging fundamental physical quantity. Instead, the fundamental physical quantity representing the object is the amount of electric charge within it, which is definite and unchanged for any given object.

In Eqs. (18) and (20), the polarizability α describes how the electric field generated by one macroscopic object affects the randomly oriented, directional, non-uniform charge distribution within another macroscopic object in both manner and rate.

First, the mutual influence between two objects depends on the strengths of their electric fields, which in turn depend on the distance R between the two objects. Thus, α should be a function of R. Second, as mentioned above, according to the principle of energy conservation, the interaction force strength between two macroscopic objects should change with the square of the distance R between them. Lastly, as also mentioned above, the farther apart the two objects are, the higher the sensitivity to changes in their charge distributions. Therefore, we may consider α as a function that is proportional to the square of the distance R, that is, $\alpha = \beta R^2$, where β (SI unit: C/Vm coulomb per volt-meter) is a proportional constant).

In Eqs. (18) and (20), the value of γ depends mainly on the mass ratio of the two objects considered (assuming their physical properties, such as compositions, substance states, and so on, are not significantly different; for example, both objects are in solid state), so its minimum value is 1. When considering the attraction between a star and a planet within the solar system, such as the Earth and the Sun, since the mass of the Sun is $1.989 \times 10^{30} kg$, and the mass of the Earth is $5.972 \times 10^{24} kg$, the value of γ is 3.3×10^5. When considering the attraction between the Earth and a measurement sample on the Earth's surface for testing gravitational force change accuracy, since the Earth's mass is 5.972×10^{24}kg, and the mass of a normal sample can't exceed 1000kg, the value of γ is less than 5.97×10^{21}.

Since $\alpha = \beta R^2$, Eq. (20) becomes

$$m_{E1} = \sqrt{6}\, p_{1\infty}\frac{2\pi\varepsilon_0}{2\pi\varepsilon_0 R - \beta\gamma}. \quad (21)$$

Thus, based on the first physical mechanism, the author may confirm that the dipole model theory is highly consistent with Newton's law of gravity. Specifically, the rate of change in gravitational force strength, as deduced by the dipole model theory, is approximately and inversely proportional to the square of the distance. This consistency aligns well with actual observations and measurements.

The method of confirmation involves demonstrating that the equivalent mass, m_{E1}, of the object 1 remains constant; that is, the equivalent mass m_{E1} is not related to the distance R. If the equivalent mass can remain unchanged, any deviation should be zero, or at least smaller than the measurement

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errors tested with modern technology. Therefore, the first step is to calculate the relative change rate deviation, χ_1 or χ_2, of the equivalent mass m_{E1} or m_{E2} after a distance change of $R = L$. The definitions of χ_1 and χ_2 are provided below.

$$\chi_1 = \frac{m_{E1L} - m_{E11}}{m_{E11}}. \quad (22)$$

$$\chi_2 = \frac{m_{E2L} - m_{E21}}{m_{E21}}. \quad (23)$$

In Eqs. (22) and (23), m_{E1L} or m_{E2L} is the equivalent mass of object 1 or object 2 at the distance of $R = L$ meters, m_{E11} or m_{E21} is the equivalent mass of object 1 or object 2 at the distance of $R = 1$ meter. Obviously, when the distance change L is larger and the relative change rate deviation χ_1 or χ_2 is smaller, the value of equivalent mass m_{E1} or m_{E2} is closer to be constant. In other words, when the value of L is larger and the value of χ_1 or χ_2 is smaller, the change rate of the gravitational force strength of an object, predicted by the dipole model theory, is closer to be inversely proportional to the square of the distance R from that object.

Since numerous factors influence the interaction between two macroscopic objects, such as the types, quantities, spatial arrangements, densities, and temperatures of the atoms and molecules within them, estimating the polarizability value of a macroscopic object is difficult. Here, the calculations can only be simplified, resulting in resulting in some approximation errors. However, this does not affect the overall conclusion.

Du to polarizability values of various atoms composing any object range from ~0.6 to ~60, for example, hydrogen (H) is 0.667, iron (Fe) is 8.4, sodium (Na) is 24.11, potassium (K) is 43.06, and cesium (Cs) is 59.6 (SI units: Cm^2/V coulomb-meter squared per volt) [15], and any value of the polarizability within the range of 0.6 to 60 does not substantially affect the calculation results, a typical value of $\beta = 16$ is roughly assumed. After substituting this value and $\varepsilon_0 = 8.854187818 \times 10^{-12} F/m$ (SI units: faraday per meter) into Eq. (22), the relative change rates deviation χ_1 of the equivalent mass m_{E1} of the object 1 with different distance changes L can be obtained, as shown in Table 2, Table 3 and Table 4. In Table 2, $\gamma = 1$, in Table 3, $\gamma = 10^5$, in Table 4, $\gamma = 10^{21}$, and the unit of distance L is thousand meters (*km*).

Table 2. Relative Change Rate Deviation χ_1 of Equivalent Mass m_{E1} with Distance Change L ($\beta = 16$, $\gamma = 1$) .

L (km)	1.00E-03	1.00E-02	1.00E-01	1.00E+00	1.00E+01	1.00E+02	1.00E+03	1.00E+04
β	16	16	16	16	16	16	16	16
γ	1	1	1	1	1	1	1	1
χ_1		3.13E-11	3.44E-10	3.47E-09	3.48E-08	3.48E-07	3.48E-06	3.48E-05
L (km)	1.00E+05	1.00E+06	1.00E+07	1.00E+08	1.00E+09	1.00E+10	1.00E+11	1.00E+12
β	16	16	16	16	16	16	16	16
γ	1	1	1	1	1	1	1	1
χ_1	3.48E-04	3.49E-03	3.59E-02	5.15E-01	9.16E-01	2.55E+00	3.39E+01	3.47E+02

Table 3. Relative Change Rate Deviation χ_1 of Equivalent Mass m_{E1} with Distance Change L ($\beta = 16$, $\gamma = 10^5$) .

L (km)	1.00E-03	1.00E-02	1.00E-01	1.00E+00	1.00E+01	1.00E+02	1.00E+03	1.00E+04
β	16	16	16	16	16	16	16	16
γ	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
χ_1		2.89E-16	3.47E-15	3.49E-14	3.48E-13	3.48E-12	3.48E-11	3.48E-10
L (km)	1.00E+05	1.00E+06	1.00E+07	1.00E+08	1.00E+09	1.00E+10	1.00E+11	1.00E+12
β	16	16	16	16	16	16	16	16
γ	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
χ_1	3.48E-09	3.48E-08	3.48E-07	3.48E-06	3.48E-05	3.48E-04	3.49E-03	3.59E-02

Table 4. Relative Change Rate Deviation χ_1 of Equivalent Mass m_{E1} with Distance Change L ($\beta = 16$, $\gamma = 10^{21}$) .

L (km)	1.00E+06	1.00E+07	1.00E+08	1.00E+09	1.00E+10	1.00E+11	1.00E+12	1.00E+13
β	16	16	16	16	16	16	16	16
γ	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21
χ_1		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L (km)	1.00E+14	1.00E+15	1.00E+16	1.00E+17	1.00E+18	1.00E+19	1.00E+20	1.00E+21
β	16	16	16	16	16	16	16	16
γ	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21	1.00E+21
χ_1	3.21E-16	3.53E-15	3.47E-14	3.48E-13	3.48E-12	3.48E-11	3.48E-10	3.48E-09

From Table 2–4, it can be seen that when the mass ratio γ of the two objects is 1, the relative change rate deviation χ_1 of the equivalent mass m_{E1} does not exceed one ten-thousandth (χ_1<10^{-4}) within the range of distance change L from 1 meter to ten thousand kilometers ($L = 10^4 km$). When the mass ratio γ of the two objects is 100,000 ($\gamma = 10^5$), the relative change rate deviation χ_1 of the equivalent mass m_{E1} does not exceed one ten-thousandth (χ_1<10^{-4}) within the range of distance change L from 1 meter to one billion kilometers ($L = 10^9 km$). When the mass ratio γ of the two objects is 10^{21} ($\gamma = 10^{21}$), the relative change rate deviation χ_1 of the equivalent mass m_{E1} does not exceed one billionth (χ_1<10^{-9}) within the range of distance change L from 1 meter to one hundred billion billion kilometers ($L = 10^{21} km$).

If the maximum corresponding distance where the relative change rate deviation, χ_1, of object equivalent mass, m_{E1}, is less than a certain value, such as one ten-thousandth (χ_1<10^{-4}), is defined as the "effective distance," R_E, where the inverse square law holds highly approximately, then from Table 2, Table 3, and Table 4, it can be seen that when γ = 1, the "effective distance" is ten thousand kilometers ($R_E = 10^4 km$); when $\gamma = 10^5$, the "effective distance" is one billion kilometers ($R_E = 10^9 km$); and when $\gamma = 10^{21}$, the "effective distance" is much longer than one hundred billion billion kilometers ($R_E \gg 10^{21} km$). Please note that, for the Sun, the relation of $p_2 \approx \gamma p_1$ should no longer strictly hold, because the physical properties of the Sun differ significantly from some other normal objects, including the Earth.

So far, precise measurements of gravitational force strength were conducted on the Earth's surface, with the highest precision being about 10^{-9} [16]. As mentioned above, the mass ratio γ between the Earth and a possible measurement sample is not greater than 5.97×10^{21}. Therefore, in the physical environment on the Earth's surface, the accuracy of the change rate of the gravitational force strength established based on the dipole model theory is far higher than the measurement error of modern technology. Thus, the dipole model theory of gravitational force is entirely consistent with the results of countless precise measurements. It should be noted that, so far, the observations and measurements of the gravitational force were conducted on the Earth's surface and in the Earth's nearby space.

From Eq. (21), the gravitational force based on the dipole model theory has the following characteristics:

1. The change in the strength of gravitational force, which is inversely proportional to the square of the distance, or the equivalent mass of an object being constant, depends on the distance between the interacting objects. This implies there is an "effective distance" for these conclusions to hold true.
2. The "effective distance" depends on the mass ratio of the two attracting objects; the larger the mass ratio, the greater the "effective distance".
3. The "effective distance" also depends on the polarizabilities of the two attracting objects and is thus related to their physical properties, including composition, density, state, temperature, etc.
4. When $R \Rightarrow \frac{\beta\gamma}{2\pi\varepsilon_0}$, the equivalent mass (and so-called mass) of the interacting object increases very fast and nonlinearly. Conversely, when $R \Rightarrow \infty$, the equivalent mass (and so-called mass) of the interacting object approaches zero. This may provide an additional possible way to solve the

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mystery of dark matter and explain why celestial systems have finite sizes. First, because when the distance R is great, the equivalent mass (and so-called mass) of the interacting object increases rapidly, celestial bodies on the far outskirts of a rotating galaxy will not be thrown out of the galaxy due to excessive rotational speed. Thus, dark matter may not be required. Second, objects that are too far from the center of the galactic system will have their equivalent mass (and so-called mass) decrease rapidly, causing them to leave the galactic system. Therefore, any galactic system may only capture celestial bodies within a certain distance, resulting in a finite size. Certainly, there are other ways to solve the dark matter mystery. For example, celestial bodies located at the far outskirts of rotating galaxies have distinctly different physical components, states, structures, pressures, temperatures, and so on. This could lead to larger oriented directional non-uniform charge distributions, resulting in larger electric dipole moments.

The description above also explains the physical cause of the change in the rate of gravitational force strength, which is inversely proportional to the square of the distance. The inverse square rate was initially derived from observations and measurements, including the early observations of planets orbiting stars, the later Cavendish experiment, and modern precise measurements. Previous discussions on the cause of the inverse square rate have only considered it to be due to the spherical divergence of a uniform field emanating from a point, thus making it seem natural. However, this work provides a real physical explanation for its cause.

Of course, if Eq. (21) is used to calculate the weight difference of the same object on the Earth's surface and the Moon's surface, the calculation results will have an error of nearly one order of magnitude. For Eq. (21), which is a simplified formula established under approximate assumptions, having only an order of magnitude error in celestial calculations on a cosmic scale should be quite acceptable.

6. Field Strengths and Moment Lengths of Induced Dipoles of Typical Objects and Celestial Bodies

Below, the values of induced electric dipole moments for some typical objects and celestial bodies, as well as the corresponding electric field strengths and dipole moment lengths, are calculated. First, using the Earth and the Moon as examples: if the mass of the Earth is M_E and the mass of the Moon is M_M, then from Newton's Equation (11), the gravitational attractive force $\vec{F}_{EM}$ between the Earth and the Moon is

$$\vec{\boldsymbol{F}}_{\boldsymbol{EM}} = G\frac{M_E M_M}{R^2}\vec{\boldsymbol{R}}. \tag{24}$$

In the section "Strength Change Rate of Gravitational Force with Distance," the analysis and calculations show that within the “effective distance,” the change rate of the attractive electric force strength may approximately follow the inverse square law. Thus, when supposing P_E and P_M are the induced electric dipole moments of the Earth and the Moon, respectively, then $P_E = r_E q_E$, and $P_M = r_M q_M$. Here r_E, r_M, q_E and q_M are the lengths and charge amounts of the induced electric dipole moments of the Earth and the Moon due to their interaction. Therefore, the electrical attractive force $\vec{\boldsymbol{F}}_{\boldsymbol{DEM}}$ between the Earth and the Moon, according to the electric dipole theory of gravitational force, may be approximately expressed as:

$$\vec{\boldsymbol{F}}_{\boldsymbol{DEM}} \doteq \frac{1}{4\pi\varepsilon_0}\frac{6P_E P_M}{R^2}\vec{\boldsymbol{R}}. \tag{25}$$

Because $\vec{\boldsymbol{F}}_{\boldsymbol{DEM}} = \vec{\boldsymbol{F}}_{\boldsymbol{EM}}$, we have

$$G\frac{M_E M_M}{R^2} \doteq \frac{1}{4\pi\varepsilon_0}\frac{6P_E P_M}{R^2}. \tag{26}$$

Assuming the Earth and the Moon are composed of approximately the same material, the lengths of the induced electric dipoles, r_E and r_M, should change at approximately the same rate with the strength of the electric field. Additionally, since the number of electric charges within the Earth and the Moon, q_E and q_M, should be proportional to their masses, M_E and M_M, respectively, we have:

$$\frac{M_E}{M_M} \approx \frac{P_E}{P_M}. \tag{27}$$

And thus

$$P_M \approx \frac{M_M}{M_E} P_E. \tag{28}$$

Substituting Eq. (28) into Eq. (26), we obtain

$$P_E = \sqrt{\frac{1}{6} G 4\pi\varepsilon_0} M_E. \tag{29}$$

In Eq. (29), G represents the gravitational constant. The Eq. (21) allows for the calculation of the Earth's induced electric dipole moment, denoted as P_E. The results of this calculation are presented in Table 5.

Eq. (29) indicates that the value of Earth's electric dipole moment is determined solely by its own physical parameters. Although every macroscopic object inherently possesses an electric dipole, the orientation of this dipole can be influenced by external objects. Therefore, the theoretical calculation of a macroscopic object's electric dipole moment should consider the influence of external objects. However, Eq. (29) does not account for this influence, which may be due to various approximations made earlier.

Knowing P_E value allows us to calculate the electric field strength E_P of P_E in the direction of the dipole moment P_E

$$E_{DE} = \frac{1}{4\pi\varepsilon_0} \frac{2P_E}{r^3}. \tag{30}$$

Please note that in Eq. (30), the electric field strength of the dipole, P_E, is still inversely proportional to the cube of the distance r, which is the standard expression for the electric field strength of a dipole. This does not contradict the previously derived result, which states that the attractive force strength between two dipoles is inversely proportional to the square of the distance between them. This result is just derived based on the standard expression for the electric field strength of a dipole.

When the Earth's radius is used as the value of r in Eq. (30), the calculated electric field strength, E_{DE}, is the electric field strength at the Earth's surface. The calculation results are also shown in Table 5.

Table 5. Field Strengths and Moment Lengths of Induced Dipoles of the Sun, the Earth, the Moon and a Human Body.

Object	Mass (M, kg)	Radius (r, m)	Dipole Moment (P, mC)	Dipole Field (E_D, V/m)	Dipole Length (L_{DA}, m)	Dipole Length (L_{DB}, m)
Sun	1.99E+30	6.95E+08	6.99E+19	3.75E+03	3.67E-19	4.00E-22
Earth	5.97E+24	6.37E+06	2.10E+14	1.46E+04	3.67E-19	4.00E-22
Moon	7.35E+22	1.74E+06	2.58E+12	8.87E+03	3.66E-19	3.99E-22
Human Body	1.00E+02	4.00E-01	3.51E-09	9.88E+02	3.66E-19	3.99E-22

Table 5 shows that, on the Earth's surface, the electric field strength generated by the Earth's induced electric dipole is 1.46×10^4 volts per meter. This differs by one to two orders of magnitude from the actual observed value of about 100 volts per meter. One reason for this discrepancy is that the calculations are based on several simplifications and approximations. These include simplifying the complex effects of the polarizations of a vast number of atoms and molecules within the Earth and Moon into two ideal electric dipoles, as well as approximations of the physical properties of the Earth and Moon. For example, the dayside and nightside of the Moon are always positively and negatively charged, which is entirely different from the distribution of electric charges on the Earth's surface. Another reason for this discrepancy is that the spatial electric field on the Earth's surface is influenced by many factors, including variations in the Earth's magnetic field, the flow of liquid metal in the Earth's outer core, ionospheric currents, solar wind, solar flares, and tidal forces caused by the gravitational pull of the Sun and Moon. Given these complex influences, a discrepancy of one to two

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orders of magnitude in the calculation for a massive celestial body like the Earth should be considered acceptable and should not affect the essential physical conclusion. It is important to note that even a voltage of 1.46×10^4 volts per meter would not cause air breakdown or result in electrical sparks in the air.

Next, the length, L_{ED}, of the induced dipole moment of the Earth when interacting with the Moon is calculated. For this, we need to calculate the total number of charges on Earth.

Starting from the currently generally accepted perspective, which considers that a proton contains only one positive charge and a neutron contains no charge, the Earth is approximately neutral. Therefore, the total number of protons in the Earth should equal the total number of electrons. Let the total number of electrons in the Earth be N_{EA}. Since the mass of an electron is much smaller than the mass m_p of a proton or the mass m_n of a neutron, and the mass of a proton or a neutron is approximately $m_p = m_n = 1.67 \times 10^{-27}$ kilograms, thus

$$N_{EA} \approx \frac{M_E}{m_p} = 3.57 \times 10^{51}. \quad (31)$$

Where M_E is the mass of the Earth. Here, it is assumed that the number of neutrons inside the Earth is obviously smaller than the number of protons, so the number of neutrons is not calculated.

Afterwards, calculations are made from the perspective of the photon electric dipole model. As described above and below, this perspective considers that each proton and neutron within an atom is composed of multiple photons, and each photon is composed of a pair of positive and negative electrons. Thus, since the mass of an electron is $m_e = 9.11 \times 10^{-31}$ kg, we obtain the total number of charges contained in the Earth, N_{E2B} (assuming the mass of a positron is the same as that of an electron).

$$N_{E2B} \approx \frac{M_E}{m_e} = 6.56 \times 10^{54}. \quad (32)$$

Since this number includes both positive and negative charges, the total number of electrons, N_{EB}, should be half of the total number of charges, N_{E2B}. Thus, since the Earth's electric dipole moment, P_E, equals the dipole length L_{EDA} or L_{EDB} multiplied by the total positive or negative charges, $N_{EA}q_e$ or $N_{EB}q_e$, we have

$$L_{EDA} = \frac{P_E}{N_{EA}\, q_e} \text{ or } L_{EDB} = \frac{P_E}{N_{EB}\, q_e}. \quad (33)$$

where q_e is the electron charge. By substituting the value of the Earth's electric dipole moment, P_E, given in Table 5, and the number of charges, N_{EA} or N_{EB}, the length of the induced Earth's electric dipole can be obtained, and the calculation result is also shown in Table 5. Here, L_{EDA} is the calculation result based on the currently generally accepted perspective, and L_{EDB} is the calculation result based on the photon electric dipole model perspective.

Following the same calculation process described above, we can calculate the induced electric dipole moment, electric dipole field strength, and dipole length of the Sun, the Moon, and a common human body as they interact with the Earth. The relevant calculation results are shown in Table 5. Please note that, in Table 5, M, r, P and E_D represent mass (unit: kg kilogram), radius (unit: m meter), moment (unit: Cm coulomb-meter) and field strength (unit: V/m volt per meter) of the induced electric dipole of the Sun, the Earth, the Moon and the human body. L_{DA} and L_{DB} represent moment length (unit: m meter) of the induced electric dipole of the Sun, the Earth, the Moon and the human body. L_{DA} is calculated based on generally accepted perspective, and L_{DB} is calculated based on photon electric dipole model perspective.

Table 5 shows that, based on generally accepted perspective or photon electric dipole model perspective, the length of the induced Earth's electric dipole is 10^{-19} or 10^{-22} meters. Since the scale range of atomic diameters is 0.1-0.5 nanometers (1 nanometer = 1×10^{-9} meters), and the scale range of atomic nucleus diameters is 2-15 femtometers (1 femtometer = 1×10^{-15} meters), and electrons are generally considered to be fundamental point particles without a truly measurable diameter, but for theoretical analysis and calculation, the electron is assumed to have a "classical diameter" of 5.6 femtometers. It is evident that the length of the induced Earth's electric dipole is extremely small, even smaller than the diameter of an atomic nucleus or the "classical diameter" of an electron. As mentioned above, here, the the induced Earth's electric dipole length is an abstract

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physical concept describing the synthetic property of directional non-uniform charge distribution formed by a large number of charged particles. It is not the real distance between any two actual charged particles.

Due to the Earth's rotation, the Moon's rotation around the Earth, and the Earth's rotation around the Sun, the induced Earth's electric dipole continuously rotates, generating a current and dissipating energy. So, how large is this induced current and energy dissipation? Could it cause electromagnetic noise or even heat the Earth? Below, we estimate this, only based on the generally accepted physical perspective.

To simplify the calculation, considering the Earth as an ideal electric dipole. Because this dipole is composed of two equal and opposite point charges, $\pm q_E = \pm N_{EA} q_e = \pm 5.71 \times 10^{32}$ coulombs, with the two point charges located on either side of the dipole center at a distance of L_{DA}, the electric dipole rotates uniformly around its center. Each point charge moves in a circle with a radius of $L_{DA}/2$, and the rotation period is T .

According to the definition of current I, I is equal to the amount of charge passing through a cross-section per unit time. Since the positive and negative point charges at the ends of the electric dipole both participate in the rotation, the equivalent current intensity is

$$I = \frac{2N_{EA}q_E}{T}. \quad (34)$$

If the rotation period is 24 hours, then $T = 86400$ seconds. If the rotation period is 30.5 days, then $T = 2\,635\,200$ seconds. Thus, for a rotation period of 24 hours, $I \approx 1.32 \times 10^{28}$ amperes, and for a rotation period of 30.5 days, $I \approx 4.33 \times 10^{26}$ amperes.

Although the current generated by the rotation of the induced Earth's electric dipole is large, the oscillating electromagnetic radiation power caused by an extremely small rotating (oscillating) dipole is very low due to the extremely short dipole length and its slow rotation speed. Below, the radiation power and energy dissipation produced by one complete rotation of the induced Earth's electric dipole are calculated.

If the Earth's electric dipole moment, P_E, rotates uniformly with an angular frequency $\omega = \frac{2\pi}{T}$, the produced dipole electromagnetic radiation power P_ω is [17]

$$P_\omega = \frac{\omega^4 P_1^2}{6\pi\varepsilon_0 C^3}, \quad (35)$$

where $\varepsilon_0 = 8.854 \times 10^{-12}$ faradays per meter, and $C = 2.998 \times 10^8$ meters per second.

Thus, for a rotation period of 24 hours, $\omega \approx 7.27 \times 10^{-5}$ radians per second, $P_\omega \approx 2.74 \times 10^{-4}$ watts. The corresponding dipole single-circle radiation energy is $E_D = P_\omega T \approx 23.7$ joules.

For a rotation period of 30.5 days, $\omega \approx 2.38 \times 10^{-6}$ radians per second, $P_\omega \approx 3.17 \times 10^{-10}$ watts. The corresponding dipole single-circle radiation energy is $E_D = P_\omega T \approx 8.35 \times 10^{-1}$ joules.

Such a small amount of electromagnetic radiation power will not produce noticeable electromagnetic noise, and similarly, such a small amount of energy dissipation will not cause noticeable heating on the Earth.

However, the actual rotational oscillation electromagnetic radiation and energy dissipation produced by the Earth's electric dipole are not so small. This is mainly because considering the Earth's positive and negative charge distribution as an ideal electric dipole is overly simplistic, especially since the centers of the two point charges of the dipole are almost entirely located at the Earth's center. In reality, the rotation of positive and negative charges located in the Earth's shallow layers causes greater electromagnetic radiation and energy dissipation. For example, the rotation of the Earth's magnetic field dissipates a significant amount of energy. However, as mentioned above, the polarization displacement of atoms and molecules within the Earth caused by external celestial electric fields is small and therefore cannot cause noticeable electromagnetic radiation and energy dissipation.

7. Fundamental Difference Between Gravitational and Electric Forces

The fundamental difference between gravitational force and electric force is that electric force is a simple force, acting as a single force between an electric field and either positive or negative charge(s). In contrast, gravitational force is a synthetic force, acting as a combined force between an electric field and both positive and negative charges simultaneously. These two forces exhibit significantly different characteristics and behaviors.

1. Electric force has a distinct directionality and bipolar nature, meaning it is anisotropic. The force between two charged objects can be either attractive or repulsive. Gravitational force, on the other hand, lacks directionality and bipolar nature.
2. Although gravitational force is inherently anisotropic, due to dynamic and rapid self-calibration process, it becomes isotropic, and the force between two electrically neutral objects is only attractive.
3. The strength of gravitational force is far weaker than that of electric force. This is because, under normal circumstances, the number of positive and negative charges within ordinary objects is almost equal, and the forces exerted by the electric field on positive and negative charges are nearly equal but opposite in direction. As a result, the attractive and repulsive forces of the electric field on an object almost completely cancel each other out, leaving a very small net difference. This minute net difference in force is what constitutes gravitational force, which is much weaker than that of electric force, about 10^{36} to 10^{40} times weaker.

For a long time, the distinctly different appearances and characteristics of these two forces have led people to firmly believe that gravitational force is not electric force. This has been the fundamental reason why people have long been unable to correctly understand the nature and origin of gravitational force.

Truths of the Confusing Phenomena Related with Gravitational Force

Due to its particular characteristics, gravitational force exhibits strange and mysterious behaviors, leading to confusing phenomena observed in the universe. Some of these phenomena have puzzled humans for a long time. However, with new understandings of gravitational force, these confusing phenomena can be effectively explained. On the other hand, these phenomena may be regarded as indirect evidence supporting the correctness of the dipole model theory of gravitational force.

1. Formation of the Solar System and Milky Way Galaxy

Based on the electric dipole model theory, the author can explain the centripetal attraction of the Earth to everything on its surface, as well as the formation of the Earth-Moon system, the Solar system, and the Milky Way galaxy effectively.

First, as indicated above, measurements have shown that the Earth's surface is negatively charged, resulting in a downward electric field surrounding it, that is, a centripetal electric field is surrounding the Earth. The magnitude of this field is about 100 volts per meter at ground level. Thus, for any object on the Earth's surface, whether it is initially electrically neutral or charged, the Earth's electric field will induce a oriented directional non-uniform distribution of free and induced net electric charges in that object, as shown in Figure 7.

Since the Earth's surface field is toward the Earth's center, in every object on the Earth's surface, the free positive charges will be pushed toward the ground, and the free negative charges will be pulled away from the ground, causing the net positive and net negative charges to be distributed in the red and blue regions in the object, respectively. Additionally, the distribution center of all induced net positive charges will move close to the ground, while the distribution center of all induced net negative charges will move farther from the ground.

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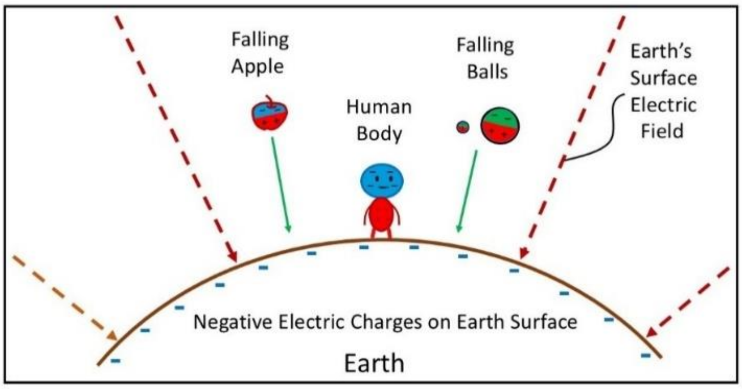

Figure 7. Under the Earth's surface electric field, every object's inherent electric dipole is oriented to the Eart's center. Thus, every object on the Earth's surface is attracted by the Earth's electric force, that is, the Earth's gravitational force.

Please note that not all net negative charges within any object on the Earth's surface move to the blue region of the object, and not all net positive charges move to the red region within the object. This is because, in the most polar molecules, polarized atoms and molecules, although the positive and negative charges move under the Earth's electric field, still remain within these atoms and molecules. Please refer to Figure 2. The blue and red regions in Figure 7 are a figurative representation.

Thus, in every object on the Earth's surface, the oriented directional non-uniform distribution of the free and induced net electric charges will make this object's electric dipole toward the Earth's center. Therefore, every object, as a small electric dipole, will be attracted by the Earth's surface electric field, that is, the Earth's gravitational force. Such objects include everything on Earth's surface, including every person standing on the ground, the two metal balls thrown from the Leaning Tower of Pisa by Galileo, and the apple that fell from the tree and hit Newton.

The Earth's surface electric field is not uniform. The strength of the electric field on the Earth's surface changes with the height of the measured location; that is, the farther a location is from the Earth's surface, the weaker the electric field strength. Measurements have shown that the Earth's atmospheric electric field strength decreases significantly with increasing height due to the conductivity of the upper atmosphere and the concentration of charge at lower altitudes [18]. Thus, although an ideal electric dipole has equal positive and negative charges, the Earth's electric field strengths at the induced positive and negative charge centers of an object on the Earth's surface are different. As a result, the Earth's attractive and repulsive forces exerted on an object cannot be canceled, and the attractive force is larger than the repulsive force.

The Moon also has an electric field, which will interact with the Earth's electric field too. Thus, an interaction electric force is generated between the Earth and the Moon, as shown in Figure 8.

The Moon's nightside is negatively charged, while its dayside surface is positively charged [11]. Thus, the Moon becomes a typical electric dipole with its moment direction toward Earth. Although the Earth's entire surface is negatively charged and has a surrounding and centripetal electric field, the Earth may still become a generalized electric dipole. First, the electric charge distribution in Earth's interior is very complicated and continually changing; thus, there is almost no chance that the Earth's electric charge distribution is exactly centrally symmetric. In addition, with the Moon's non-stop rotation around the Earth, the Moon's electric field will certainly cause Earth's charge distribution to reform into new equilibrium state continually. The Earth's tides caused by the rotation of the moon are manifestation of the similar interaction. As a result, for example, the net negative charges on the surface of the Earth's side facing the Moon can be appropriately more than the net negative charges on the surface of the Earth's side away from the Moon. Due to the conservation of electric charge for the whole Earth, the net positive charges on the surface of the Earth's side facing the Moon will be correspondingly less than the net positive charges on the surface of the Earth's side away from the Moon. This will produce a generalized electric dipole in the Earth in response to the Moon's electric dipole. Thus, even if all of the Earth's surface is negatively charged, the overall charge distribution of the Earth may still form a generalized electric dipole in response to the Moon. In Figure 7, we can see that the direction of the Moon's electric dipole moment aligns with the direction of the Earth's surface electric field and should be the same as the moment direction of the Earth's generalized electric dipole. Thus, an attractive electric force is generated between the Earth and the Moon, causing the Moon to rotate around the Earth with only its dayside facing the Earth permanently. Because the Earth only attracts the dayside of the Moon, observers on Earth never see the nightside of the Moon.

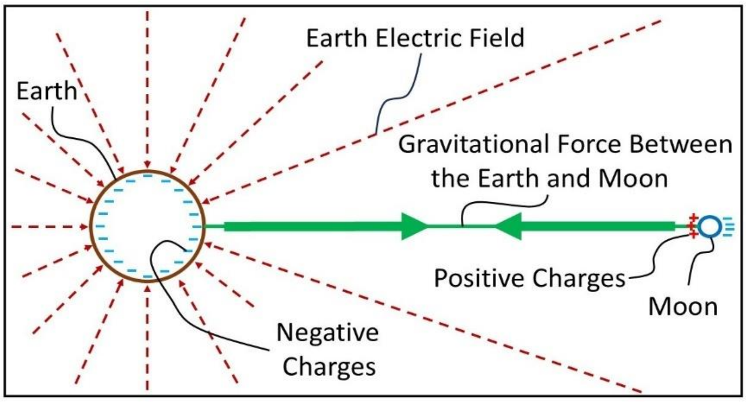

Figure 8. The Earth's surface is negatively charged, and the Moon's dayside surface is positively charged. Thus, an attractive electric force between the Earth and the Moon is generated, which is the origin of the gravitational force between the Earth and the Moon.

The peculiar charge distribution on the Moon's surface is likely due to its internal electrical structure. However, the influence of Earth's electric field on the Moon cannot be ignored. The negative charges on Earth's surface can push more negative charges on the Moon to its far side.

Besides Earth, the Moon is affected by other celestial bodies, such as the Sun, Mars, Venus, and Mercury. However, compared to Earth's electric field, the electric fields of these other celestial bodies, including the Sun, are weak. This allows the Moon to rotate around Earth, forming the Earth-Moon system.

Observations show that the Sun's electromagnetic field is complex, primarily generated by the movement of charged particles within the Sun and influenced by its rotation and temperature. The solar wind, a stream of charged particles released from the Sun's outermost atmospheric layer, affects both Earth and the Moon.

These observations indicate that the charge distribution inside the Sun is extremely non-uniform, turning the Sun into an electric dipole-like or a generalized electric dipole-like massive macroscopic object. The electric dipole formed by the Sun interacts with the electric dipole formed by the Earth, affecting the charge distributions in both. Naturally, the influence of the Earth on the Sun is much smaller than that of the Sun on the Earth, due to the Sun's significantly greater mass and higher temperature. Consequently, the interaction between Earth and the Sun reaches an equilibrium state at every moment. When the electrical interaction force between these two dipoles becomes attractive, the equilibrium state is stable, resulting in Earth orbiting the Sun. The measured daily periodic variation curves of Earth's surface space electric field strength provide clear evidence of the strong electric field interaction between Earth and the Sun.

The author suggests that within Earth's interior, the complex charge distribution can form two main separate electric dipoles to respond to the Sun and Moon simultaneously. This charge distribution can change continually, accompanied by the rotation of the Moon around Earth and Earth around the Sun. In other words, Earth can attract various small objects on its surface in all directions, as well as two particularly large objects in two changing directions with attractive electric

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forces. Although this situation is complex, due to the ease and speed of charge distribution changes, it is entirely possible. This complexity has long challenged our understanding of the nature of gravitational force.

Thus, Earth, as a large generalized electric dipole, is attracted by the Sun, a much larger electric dipole or generalized electric dipole. Consequently, the Earth-Moon system, along with other planet-satellite systems like those of Mars, Venus, and Mercury, rotates around the Sun, forming the Solar System.

According to current knowledge, there are hundreds of billions of planetary systems, including our Solar System, in the Milky Way galaxy. These systems may be similar to or different from our Solar System. Although they are far away and little is known about them, one thing is certain: based on spectral analyses, these systems consist of the same microscopic and subatomic particles as our Solar System, including photons, electrons, protons, neutrons, various atoms, and molecules. Since these particles move, combine, and split depending on electric forces, the dynamically self-calibrating process can cause multiple electric dipoles, or even groups of electric dipoles, to mutually and continuously attract each other. The author is confident that the gravitational force originating from electric attractive forces exists in these planetary systems and plays a fundamental role.

Therefore, apart from the fact that the entire Milky Way galaxy is formed based on electric forces, such inferences can be applied to larger-scale systems, such as galaxy clusters (Local Group) and even the whole universe.

2. Causes of Flat Galaxies and Filamentary Nebulae

Almost all observed celestial systems, including the Solar System, the Milky Way galaxy, and many other galaxies, have approximately flat, spherical shapes. Why do these celestial systems have flat shapes, and how can we explain their formation? The author provides answers, suggesting that these shapes are caused by the anisotropy of the gravitational field, as expressed by Eqs. (2), (3), (4), and (5). Most celestial bodies can be regarded as electric dipoles or generalized electric dipoles, and the attractive force of an electric dipole is along the direction of the dipole moment. This means any two celestial bodies are attracted to each other along a line, or multiple celestial bodies are attracted to each other along a plane. When numerous celestial bodies are attracted to each other and to a strongest attractive center simultaneously, they move toward the strongest attractive center along various paths. The various rotational lines and planes experience anisotropic forces from nearby attractive celestial body groups and the strongest attractive center, tending to form a common plane consisting of various rotational line-like and plane-like celestial body groups. Thus, numerous celestial bodies form an approximately flat, spherical spatial distribution from their previous random spatial distribution. The rotation of the strongest attractive center and the rotations of the numerous line-like or plane-like celestial body groups also contribute to forming such a distribution. Please note that, if the gravitational force is only isotropic, flat spherical celestial systems may not be formed, at least being difficult. It is because that the gravitational force, based on electric dipole model theory, is not only anisotropic but also seemingly isotropic, flat spherical celestial systems may be formed certainly.

The Hubble Space Telescope has discovered the Filamentary Nebulae (also known as the Veil Nebulae or Cirrus Nebulae). These nebulae have immense sizes of more than 130 light-years and are located about 2,400 light-years away. This is one of the most astonishing recent discoveries in the universe. These nebulae have asymmetric and non-homogeneous structures, including filaments and loops. Remarkably, these structures challenge the consensus of the universe being homogeneous. However, they support the new understanding of gravitational force, which is that it is anisotropic. Under anisotropic gravitational fields, numerous celestial bodies, including gas, dust, planets, stars, galaxies, and galaxy clusters, are more likely to form asymmetric and non-homogeneous structures like filaments and loops of huge sizes.

3. Strange Trajectories of Some Meteors

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Recent astronomical observations have found that the trajectories of some comets entering the solar system are very strange, completely defying Newton's law of the gravitational force, such as 'Oumuamua[1] to 'Oumuamua[3], and 3I/ATLAS, etc [21, 22]. In fact, according to the gravitational theory based on the electric dipole model, the trajectories of these comets can be easily explained.

According to the electric dipole model theory, the attraction or repulsion between celestial bodies is generated by the electric fields they carry. The electric field distribution of each celestial body is determined by its physical characteristics and properties. Generally, ordinary celestial bodies are spherical in shape, and the distribution of non-uniform charges inside has roughly spherical symmetry (but still can be an electric dipole). In this case, the electric dipole moment values and attraction characteristics of these celestial bodies are relatively conventional. When such celestial bodies interact, their trajectories can follow the traditional law of the gravitational force, including forming common circular or elliptical orbits with normal acceleration or deceleration, etc. Generally, the rotation of these celestial bodies does not significantly affect their trajectories.

However, some celestial bodies have special physical characteristics and properties, such as unusual shapes, significant differences in material composition, density, temperature, etc., in different inner regions. This can lead to abnormal charge distribution inside, resulting in an electric field strength distribution that is very different from that of ordinary celestial bodies. When such celestial bodies interact with others, their trajectories cannot be predicted using the traditional law of the gravitational force. Especially when these celestial bodies rotate, their interactions with other celestial bodies may be attractive at some times and repulsive at others. Therefore, their trajectories cannot be calculated according to traditional gravitational force theory, including the abnormal rapid acceleration and deceleration.

The observed 'Oumuamua[1], for instance, has a rod-like shape, and coupled with its rotational flight, this is clearly the reason for its very strange trajectory.

4. Misconception About Dark Matter

At present, dark matter is almost a basic consensus regarding the universe's constitution. Otherwise, how can we explain why the faraway spiral arms of giant galaxies and the galaxies on the outskirts of galaxy clusters do 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 outskirts of galaxy clusters, must have much greater masses to produce the 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 sign of dark matter has been found.

The new understanding of gravitational force can solve this difficult problem effectively too. According to the electric dipole model theory, 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. (9). 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 objects' attractive forces. Thus, the celestial bodies in the galaxy spiral arms and the galaxies on the outskirts of galaxy clusters can have much larger attractive forces than estimated without much greater so-called masses, allowing them to rotate at faster speeds without collapsing.

The calculations regarding the change rate of the so-called mass with distance using Eqs. (19) and (20), as described above, also provide an additional possible way to solve the mystery of dark matter. When the distance R between the attracting bodies exceeds a certain threshold (larger than the "effective distance"), the so-called masses of the attracting objects increase rapidly. This results in additional mass beyond what is estimated, eliminating the need for dark matter.

There is no dark matter in the universe because it is not required to maintain the existence of the evolving universe.

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5. Misconception About Dark Energy

Dark energy has almost become a widely accepted concept regarding the composition of the universe. This is because a special kind of unseen energy is required to explain why distant galaxies are moving away from us at increasing speeds.

First, we must determine if the universe is expanding at an accelerated pace or even if it is expanding at a constant speed. This relates to the question of whether the "Big Bang Theory" is correct.

Many new discoveries made by the Hubble and James Webb telescopes have fundamentally shaken the foundation of the "Big Bang Theory." For example, many overmature massive galactic structures appear during the so-called early stages of the universe. According to the "Big Bang Theory," the universe began with an initial big explosion. Any celestial body and system, including stars, galaxies, and galaxy clusters, should grow gradually in line with the age of the universe. The fact that overmature massive galactic structures appear during the early stages of the universe challenges the correctness of the "Big Bang Theory."

The basic foundation of the "Big Bang Theory" is the wavelength "redshift" of the light coming from distant stars. Although the "Doppler Effect" can reduce the photon frequency and cause the light wavelength to redshift, there are also other possible reasons for light wavelength "redshift."

The author has proposed a new model of the photon [23]. Inspired by the observed phenomena of a photon appearing after electron-positron annihilation [24], and a photon splitting into an electron and a positron after a collision [25], the author suggests that the photon is composed of a positron-electron pair, making it an extremely tiny electric dipole. Additionally, since both the positron and electron have angular momentum, every photon is a rapidly rotating electric dipole [23].

In space, various electric fields exist because every celestial body has its own electric field. Compared to the rapid rotation of the photon's electric field, most spatial electric fields are almost stationary. The directions of these relatively stationary electric fields differ from the directions of the photon's rotation and straight-line motion. Consequently, both the speeds of the photon's rotation and straight-line motion are reduced, especially the rotation.

When the photon's rotation speed decreases, its frequency decreases as well [23]. This results in an increase in the photon's wavelength, leading to a "redshift" in light wavelength. Furthermore, since most celestial bodies move much slower than the speed of the photon's straight-line motion, they exert towing or resisting electric forces on the photon. Due to the "Doppler Effect," this also reduces the photon's frequency and causes the light wavelength to redshift.

Because the photon's net electric field is extremely weak and has a very short effective interaction distance, the influence of external electric fields in space on the photon is minimal. Therefore, the photon wavelength "redshift" becomes noticeable only after traveling extremely long distances from distant stars.

The light wavelength "redshift" can be considered a photon fatigue phenomenon, resulting from decreases in the photon's rotation and straight-line motion speeds. Thus, it cannot be used as key evidence to support the "Big Bang Theory."

Since the expansion of the universe doesn't exist, neither does its accelerated expansion. Some observations may show signs of accelerated "redshift," but they cannot be used as evidence of accelerated expansion of the universe.

Additionally, celestial bodies, including planets, stars, galaxies, and galaxy clusters, move in different directions and at varying speeds, including accelerated or decelerated speeds. Some move away from each other, while others move closer. However, these diverse movements, including accelerated ones, differ from the concept of universal expansion or accelerated expansion.

Because the expansion and accelerated expansion of the universe don't exist, dark energy is not required to explain anything. Even if some parts of the universe are expanding at accelerated rates, a new understanding of gravitational force can explain such phenomena. This new understanding suggests that the strength of an object's gravitational force may change continuously, such as increase continuously, with the distribution of electric charge within the object. Therefore, even if some

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regions of the universe are moving away from us at accelerated speeds, dark energy is still not required to explain such expansion. There is no dark energy in the universe.

6. Misconception About Universe's Explosion

The "Big Bang Theory" is primarily based on the belief that the "redshift" of light from distant stars is caused by the "Doppler Effect." As mentioned above, the light "redshift" can be considered a photon fatigue phenomenon, and so the light "redshift" cannot be used as key evidence to support the "Big Bang Theory." Many new observations have fundamentally broken the foundation of the "Big Bang Theory," including the discovery of more and more superfast matured massive galactic structures appearing during the so-called early stages of the universe.

Indeed, the idea that a vast and real universe can be born out of nothing is hard to believe. After so many years, some physicists, despite their intelligence, could not explain how a vast and real universe was born from an infinitely small and infinitely empty point, yet there are still many people who believe in this theory.

The universe, in fact, has no so-called age, meaning it has no start and no end. Otherwise, what existed before its start, and what will exist after its end? Similarly, the universe has no boundary. Otherwise, what exists outside the universe's boundary? Even if what is outside the universe boundary is true vacuum, the vacuum is still a part of the universe. The universe being infinite in space and time is indeed difficult to accept, but it is the easiest explanation that can be understood.

Saying that the universe has no age doesn't mean that the various parts of the universe don't evolve. Under gravitational force and repulsive forces caused by diverse reasons such as extremely high density, pressure, and temperature, these various parts of the universe may evolve in different ways and at different rates, including repeated explosions and reunions. Therefore, finding some superfast matured massive galactic structures in some parts of the universe and some super-slow growing massive galactic structures, including early-stage stars, elsewhere in the universe is normal.

7. Relationship Between Photon, Matter, and Gravitational Force

Here, the author presents a new theoretical insight: photons are not only carriers of energy and information, but they are actually the most fundamental building blocks of all matter. Thus, photons are the basic bricks that construct the edifice of the universe. Gravitational force comes from matter, and therefore photons are also the foundation of the source of gravitational force. The author indicates that the nucleus of every atom, that is, each proton and neutron within the nucleus, is composed of multiple photons, and each photon is a tiny electric dipole consisting of a pair of an electron and a positron [23]. As mentioned above, this understanding is based on four well-known physical phenomena:

1. Electron-positron annihilation, where an electron and a positron meet and annihilate to become a photon;
2. Pair production, where a photon passing through matter can instantly disappear and produce an electron and a positron [24];
3. In nuclear fission reactions, part of the nuclear material splits into a large number of (high-energy) photons [25];
4. In nuclear fusion reactions, part of the nuclear material also splits into a large number of (high-energy) photons.

These phenomena lead the author to realize that each photon is composed of an electron and a positron. In a photon, the electron and positron do not truly annihilate but are closely connected under strong electric fields with opposite signs, forming a very small electric dipole.

For each such tiny electric dipole, the electric field polarities at its ends are different. Multiple such tiny electric dipoles can approach or connect head-to-tail, then connect in series vertically, or in parallel horizontally, or in a combination of series and parallel, forming various photon clusters.

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The number of photons and the spatial structure within these photon clusters can vary. These photon clusters form various subatomic particles currently observed, including protons, neutrons, quarks, neutrinos, gluons, mesons, etc.

Due to the different structures of these photon clusters, they exhibit different characteristics.

1. Due to differences in the distribution and intensity of their combined electric fields, according to the electric dipole model theory of gravitational force, these clusters exert different electric forces out, resulting in their possessing different so-called masses;
2. Depending on whether the numbers of electrons and positrons in a photon cluster are equal or not, and the magnitude of the charge difference, these clusters can appear electrically neutral externally, such as neutrons and neutrinos, or appear positively charged externally with different positive charges, such as protons (+1e) and up quarks (+2/3e), or negatively charged externally with different negative charges, such as electrons (-1e) and down quarks (-1/3e).
3. These clusters have different stabilities, leading to different decay rates or lifetimes.

Therefore, we can say that any matter is composed of photons. For further details, see our preprint "The Origin of Light" [23].

Regarding electron-positron annihilation, the current general understanding in the physics community is that an electron and a positron form a positronium, not a photon. Positronium mainly divides into two types: parapositronium and orthopositronium. In a vacuum, parapositronium annihilates to produce two gamma photons with a short lifetime around 125 picoseconds, while orthopositronium annihilates to produce three gamma photons with a longer lifetime around 142 nanoseconds. Sometimes, positronium divides into multiple photons.

The author believes this understanding is incorrect. A clear contradiction that this misunderstanding cannot explain is: since positronium is composed of an electron and a positron, why does annihilation sometimes produce two photons, sometimes three, and sometimes multiple photons?

The author suggests the cause of this misunderstanding is as follows: during the so-called formation of positronium, the positron involved is not a single positron but a positron-photon cluster composed of a single positron and one or more photons. In this positron-photon cluster, the long-range electric field strength of each photon is very weak (because the positive and negative charges within each photon are very close, their combined electric field is only effective at short distances, allowing multiple photons to attract and adhere closely, but their long-range electric field strength is very weak). The positron's near and far electric field strengths are both strong. Therefore, the combined long-range electric field of the positron-photon cluster is very similar in strength and distribution to that of a single positron, making it easy to mistake the positron-photon cluster for a single positron.

Based on this understanding, the so-called positronium annihilation phenomenon can be easily explained. Because the so-called positron itself contains a positron and one or more photons, when such a positron-photon cluster encounters an electric field or a negative electron and splits, it naturally splits into one or more photons.

Thus, it can be reasonably concluded that in any object, including insulators, semiconductors, and conductors, there are a large number of charges (including positive and negative charges), and the total number of charges is tens to hundreds of times higher than the currently recognized total number of charges. Moreover, the number of charges in non-polar molecules and atoms is much greater than the number of charges in polar molecules, and the number of charges in polar molecules is much greater than the number of free charges.

Take Earth as an example: Earth's total mass is approximately $6 x 10^{24}$ kilograms. Assuming the Earth has an average density and that every atom within the Earth is composed of multiple photon electric dipoles, the total number of electrons (including positive and negative electrons) within the Earth should be around 10^{55} to 10^{56}. Among this enormous number of charges, only a very small portion are free charges.

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Since these photon clusters are composed of different numbers of photons and a small number of electrons or positrons, the basic components of these photon clusters are the same. In other words, the various subatomic particles currently observed have the same basic building blocks. This is very similar to how various atoms are composed of the same basic building blocks, namely electrons, protons, and neutrons.

Since people can arrange elements with similar properties, such as conductivity, into columns, and then arrange them into rows according to the periodicity of changes in physical and chemical properties, such as atomic weight, forming the Mendeleev periodic table of elements, it is clear that we can also use a similar method.

We can arrange various subatomic particles into columns and rows based on the similarity and order of changes in their physical and chemical properties, such as charge, number of photons released, lifespan, and mass, to form a periodic table of subatomic particles. Clearly, this is a meaningful and promising task, and the author will attempt to undertake this work when time permits in the future.

8. Misconception About General Relativity

People may have begun to believe in General Relativity due to its successful prediction of the bending of light as light passes near a celestial body with a large mass. However, the bending of light may also be explained more naturally in another way. As explained above, two famous observations suggest that the photon is a tiny electric dipole with a definite electric field but with a very short effect distance [23]. Although the photon's electric field can be detected only within an extremely small range around it, and so many people regard the photon as an electrically neutral subatomic particle, when the photon passes through a massive celestial body, such as the Sun, the non-uniform electric field of that celestial body will still attract the photon and bend its path, causing light bending. Note that the electric field of almost any celestial body is non-uniform, so even if the photon has rotation, it may still be effectively attracted by a celestial body with great mass. Therefore, the light bending may not be caused by non-common sensed "space-time curvature."

The fact of light bending proves that the photon's speed can change at least in the tangent direction of its straight-line motion. If the photon's speed can change in the tangent direction of its straight-line motion, then if a celestial body with huge mass is located in the normal direction of the photon's straight-line motion, such as a massive black hole, the photon's speed along the normal direction should change too.

The constancy of light speed is a fundamental postulate of special relativity. It is extended and incorporated by general relativity. In this way, the bending of light and the constant speed of light are contradictory, meaning that special relativity and general relativity cannot justify themselves.

Some other phenomena, such as Mercury's anomalous perihelion, the Shapiro time delay of signals near the Sun, and the gravitational redshift of clocks, are also believed to match general relativity. However, the reasons for the occurrence of an event can be explained in different ways. Several seemingly reasonable explanations of some physical phenomena cannot be used as evidence that general relativity is correct. The author will explain these phenomena, based on the introduced electric dipole model theory, at suitable times later and believes that these phenomena can be explained successfully.

9. 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 described by quantum mechanics as well. 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 key and hopeful door for the ultimate unification of the four fundamental forces of nature [20].

More Discussions

An important practical application of the electric dipole model theory is using electric field to alter an object's gravitational force, commonly referred to as anti-gravity, which has long been a subject of interest.

The influence of electric fields on an object’s weight has been observed before, such as in the Biefeld-Brown effect [26]. The Biefeld-Brown effect is an electrokinetic phenomenon where a force is generated on an asymmetric capacitor when subjected to high voltage, causing the capacitor to move towards the thinner electrode.

However, due to a lack of understanding of the origin and nature of gravitational force, the Biefeld-Brown effect was mistakenly attributed to “ion wind.” Furthermore, the absence of a correct and profound understanding of gravitational force has led technical research on using electric fields to alter gravity down the wrong path, significantly hindering the development of such technology and preventing its practical applications.

It must be emphasized that since the force between any two electric dipoles tends to be mutually attractive, this presents serious challenges for anti-gravity research, which must be overcome through appropriate technical means. Nonetheless, a correct and profound understanding of gravitational force is undoubtedly beneficial to the progress of anti-gravity research and applications.

In the electric dipole model theory of gravitational force, the electric dipole of each object is induced by the influence of another object. Does this mean that gravitational force is generated by gravitational force, making the electric dipole model theory of gravitational force a circular argument? This understanding is incorrect. The main reason is that the directional non-uniform electric charge distribution within an object is an inherent property. The influence of an external object merely gives this directional non-uniform charge distribution a non-random orientation. In other words, every object is inherently an electric dipole, and when there is no influence from an external object, the direction of an object’s electric dipole is randomly oriented. When influenced by an external object, the direction of this object’s electric dipole is controlled and always points towards that external object. This is very similar to the interaction between two magnets. When a magnet exists independently, although its directional non-uniform magnetic field inherently exists, it cannot be detected by others. Only when two magnets interact, either attracting or repelling each other, do people become aware that both magnets have magnetic fields.

Conclusions

This paper introduces the origin of the gravitational force, proposing that it actually originates from the electric force. Due to randomly directional non-uniform charge distribution, which is unavoidable within object, almost any object is an electric dipole or a generalized electric dipole. Thus, any two objects will interact with each other and can quickly become attracted to one another, which is the true origin of the gravitational force.

The theoretical expression for the gravitational force is provided, and the special characteristics of the gravitational force are described and explained, including the rate of change in the strength of the gravitational force, which closely follows the inverse square law of distance under certain conditions. This new understanding can effectively solve difficult problems and explain confusing phenomena, such as flat galaxies, filamentary nebulae, strange trajectories of some comets, and the formations of the Solar System and Milky Way galaxy, as well as concepts like dark matter, dark energy, superfast matured galaxies, slow-growing stars, Big Bang theory, and so on. Based on this new understanding, the gravitational force can naturally unify with the electromagnetic force, opening a hopeful door for the ultimate unification of the four fundamental forces of nature.

Compared to other existing theories of gravitational force, including generally relativity, string theory, and loop quantum gravity, no other theory can, like the electric dipole model theory of gravitational force, effectively explain so many mysterious features of gravitational force and so many puzzling physical and astronomical phenomena. This is by no means a coincidence; it is because the electric dipole model theory of gravitational force profoundly and correctly explains the origin and nature of gravitational force. Also, 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.

In summary, the electric dipole model theory appears to be effective. It not only naturally deduces characteristics of gravitational force that are consistent with reality but also can explain confusing astronomical phenomena. Where else can we find a more reasonable, effective, and commonsensical theory of gravitational force?

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