Four unified theories of field forces based on the action of electric fields

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Abstract:

The unified theory of the four fundamental forces has been a goal pursued tirelessly by physicists. Attempts have been made from various aspects such as quantum field theory, general relativity, and string theory, but none have yielded satisfactory results. This article starts with the electric field interaction between two charges. By considering the additional effect of positive and negative vacuum polarization charge clouds around the particles, the divergence equation of the electric field can not only derive the expression of the potential energy of the non-divergent electric field at zero distance, but also derive the potential energy expressions of the non-divergent nuclear force, short-range weak force, and universal gravity. These four forces are different manifestations of the static electric force between charges, and all have a non-zero equilibrium distance. The well-known Newtonian universal gravity, Coulomb force, and Yukawa nuclear force are all results when the action distance is much greater than the equilibrium distance.

Key words:

unified field theory; four kinds of interaction forces; no divergent electrostatic action; vacuum polarized charge

1、Introduction

There are four fundamental forces found in nature, namely, universal gravity, electromagnetic force, nuclear force, and short-range weak force. According to quantum field theory (QFT), these four forces are all exchange forces of spin-integer bosons, and a grand unified field theory including the short-range weak force, electromagnetic force, and nuclear force has been established from a quantum perspective [1-3]. An ultimate goal of physics is to unify all four forces, including gravity, but no one has proposed a convincing method to achieve this goal yet. Some have attempted to describe gravity using quantum field theory, but without success. Most physicists believe that novel ideas must be proposed to include gravity in the natural quantum field theory[4,5].

Quantum field theory indirectly describes the different characteristics of the three forces by analyzing the amplitude and scattering of colliding particles, rather than directly describing the different potential energies of the three forces using mathematical formulas or describing their different action laws. In particular, the mathematical expression of the potential energy of the short-range weak force, unlike the Coulomb electric field force and the Yukawa nuclear force [6,7], has not been obtained yet. Although it can be proven in the theory of electrodynamics that the potential energy of the Coulomb electric field force and the Yukawa nuclear force between two charges is inversely proportional to the square of the distance between them, there still exists the problem of infinite divergence at zero distance, which limits the application range of the potential energy of the

Coulomb electric field force and the Yukawa nuclear force. This article, based on electrodynamics theory[8-10], considers the additional effect of positive and negative vacuum polarization charge clouds around the particles, not only to solve the problem of infinite divergence of the potential energy of the Coulomb electric field force at zero distance, but also to derive the potential energy expressions of the non-divergent nuclear force, short-range weak force, and universal gravity. The Lagrangian derived from these potential energy expressions will have broad applications in quantum field theory.

2、Non-divergent electric field force at zero distance

The infinite result of the Coulomb electric field force at zero distance has always been a singularity divergence problem that physicists have been trying to solve. After more than two hundred years, no one has proposed a convincing solution. Based on the fact that the electric field strength diverges at zero distance, it can be inferred that there are positive and negative vacuum polarization charge clouds distributed around each charged particle. By considering the additional effect of these vacuum polarization charge clouds on the surrounded charge, the century-old problem of infinite divergence in the Coulomb electric field force at zero distance can be solved. The electric field strength E generated by the charge Q can be defined by introducing the electric potential φ as

$$\boldsymbol{E} = -\nabla\varphi \tag{1}$$

By substituting it into the divergence equation of the electric field,

$$\nabla\cdot\boldsymbol{E} = \rho/\varepsilon_0 \tag{2}$$

we can obtain the spherically symmetric electric potential φ that the Poisson equation,

$$\nabla^2\varphi = \frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\varphi}{dr}\right) = -\rho/\varepsilon_0 \tag{3}$$

In the equation, ε is the dielectric constant, ρ is the charge density at the field point, and r is the distance from the field point to the charge.

For the case of $\rho = 0$, equation (3) tells us that the potential of the electric field Q excited at the field point at a distance r from the charge is

$$\varphi = Q/4\pi\varepsilon_0 r \tag{4}$$

Placing a charge q at the field point, the potential energy of the electric field interaction between the two charges is

$$V = q\varphi \tag{5}$$

Therefore, the electric field interaction force between the two charges is the Coulomb electric field force

$$\boldsymbol{F} = -\nabla V = q\boldsymbol{E} \tag{6}$$

where E is the electric field intensity.

$$\boldsymbol{E} = -\nabla\varphi = \varphi \boldsymbol{r} / r^2 \tag{7}$$

Since the electric field intensity is a non-observable quantity, the divergence of the electric field intensity at zero distance does not violate physical laws. By substituting it into the Poisson equation and Gauss's theorem, it can be proven that there exist positive and negative vacuum polarization charge clouds in all uncertain spaces surrounding charged particles. The vacuum polarization charge with the opposite charge to the charged particle is concentrated at the origin of the charged particle, while the vacuum polarization charge with the same charge as the charged particle is distributed in the uncertain space outside the origin of the charged particle.

The author found that the electric field interaction between the vacuum polarization charge and the charged particles is different from the interaction of the polarized charge in the medium. It has zero net force on external charges and only exerts an electric field force on the charges it surrounds. In the absence of external charges$Q$, the vacuum polarization charge around the charge$q$ is in a state of electrostatic equilibrium and has no effect on the surrounded charge. However, when there are external charges$Q$, the charge$q$ not only experiences the electric field effect caused by the charge$Q$ but also the additional potentialφ_q caused by the electric field generated by the vacuum polarization charge surrounding the charge$q$. Therefore, the total potential$\varphi + \varphi_q$ of the charge$q$ due to the interaction with the charge$Q$must be proportional to the potential$\varphi$of the electric field excited by the charge$Q$at the charge $q$position,

$$\varphi + \varphi_q = \varphi / \chi \quad (8),$$

where χ is an undetermined function of r. Thus, considering the effect of the vacuum polarization charge, the potential energy of the electric field interaction between q and Q becomes

$$V = q\left(\varphi + \varphi_q\right) = q\varphi / \chi \quad (9),$$

which means the potential is

$$\varphi = \chi V / q \quad (10).$$

Substituting (10) into (3), the potential energy V of the electric field interaction between the two charges satisfies the equation

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2 \frac{d\left(\chi V\right)}{dr}\right) = -q\rho / \varepsilon_0 \quad (11).$$

By making the substitution $r = 1/x$, equation (11) can be written as a standard form of a non-homogeneous linear second-order differential equation

$$\frac{d^2V}{dx^2} + \frac{2}{\chi}\frac{d\chi}{dx}\frac{dV}{dx} + \frac{1}{\chi}\frac{d^2\chi}{dx^2}V = -q\rho / \varepsilon_0 x^4 \chi \quad (12).$$

Taking $\rho = 0$ as a homogeneous linear second-order differential equation

$$\frac{d^2V}{dx^2} + \frac{2}{\chi}\frac{d\chi}{dx}\frac{dV}{dx} + \frac{1}{\chi}\frac{d^2\chi}{dx^2}V = 0 \quad (13),$$

the coefficients of the homogeneous linear second-order differential equation can form a derivative term

$$\left(\frac{2}{\chi}\frac{d\chi}{dx}\right)^2-4\left(\frac{1}{\chi}\frac{d^2\chi}{dx^2}\right)=-4\frac{d}{dx}\left(\frac{1}{\chi}\frac{d\chi}{dx}\right) \qquad (14).$$

If we set this derivative term equal to zero, we have

$$\frac{1}{\chi}\frac{d\chi}{dx}=R \qquad (15),$$

where R is an integration constant. Continuing the translation:

From (15), the undetermined function can be derived as

$$\chi=\mathrm{e}^{Rx}=\mathrm{e}^{R/r} \qquad (16).$$

Thus, equation (12) can be written in the form of a constant coefficient second-order differential equation

$$\frac{d^2V}{dx^2}+2R\frac{dV}{dx}+R^2V=-x^{-4}\mathrm{e}^{-Rx}q\rho/\varepsilon_0 \qquad (17).$$

The results discussed in the mainstream are for the case of integration constant $R=0$, where $\chi=1$.

For the case of $R\neq 0$, equation (17) can be used to obtain the potential energy of the electric field force between the two charges

$$V=C_1x\mathrm{e}^{-Rx}+C_2\mathrm{e}^{-Rx}=C_1\mathrm{e}^{-R/r}/r+C_2\mathrm{e}^{-R/r} \qquad (18).$$

At $r>>R$, if it is equivalent to the potential energy of the Coulomb electric field force (5), by comparing the two equations, the constant can be determined as

$$C_1=qQ/4\pi\varepsilon_0=q\varphi r\,,\quad C_2=0 \qquad (19).$$

Therefore, the potential energy of the electric field force between the two charges can be written as

$$V=q\varphi\mathrm{e}^{-R/r} \qquad (20).$$

From this, the electric field force between the two charges is obtained as

$$\boldsymbol{F}=-\nabla V=q\boldsymbol{E}(1-R/r)\mathrm{e}^{-R/r} \qquad (21).$$

This is a non-divergent electric field force at zero distance, which can be referred to as the Xiao's electric field force. At $r>>R$, the Xiao's electric field force can revert back to the Coulomb electric field force.

The electric field force and the potential energy of the electric field force between the two charges are observable quantities, and they cannot have infinite divergent results under any circumstances. The infinite divergence of the Coulomb electric field force at zero distance indicates that the mathematical expression of the Coulomb electric field force is incomplete. In order to eliminate the infinite divergence of the Coulomb electric field force at zero distance, the integration constant R in (21) cannot be zero, and non-zero R implies that there is a minimum value for . One result that satisfies the requirement of having a minimum value for R is the relationship between and the masses of the interacting charged particles M and m , given by

$$R = \left(\hbar / Mc + GM / c^2\right) + \left(\hbar / mc + Gm / c^2\right)$$

$$= \hbar / \mu c + G\left(M + m\right) / c^2 \tag{22}$$

where $\mu = mM / \left(M + m\right)$, $\hbar$ is the reduced Planck constant, c is the speed of light, and G is the Newtonian gravitational constant. It can be easily verified that regardless of the values of M and m , will R never be less than .

Figure 1 shows the variation curves of the Xiao's electric field force and the Coulomb electric field force between a proton and an electron. It can be seen that the two electric field forces behave differently at close distances.

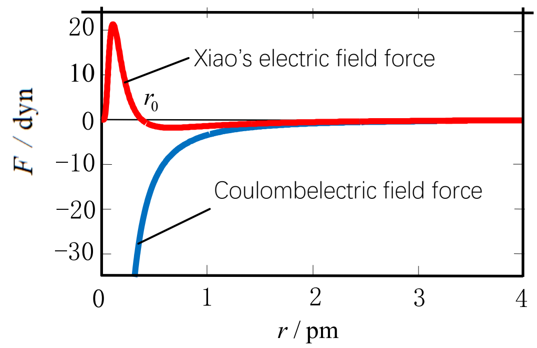


Figure 1: Variation curves of the Xiao's electric field force and the Coulomb electric field force between a proton and an electron.

When $r \to 0$, the Xiao's electric field force tends to zero, while the Coulomb electric field force tends to infinity. In addition, the Xiao's electric field force has an equilibrium distance r_0, which can be determined from $F(r_0) = 0$. The integration constant R is the equilibrium distance of the Xiao's electric field force, i.e., $r_0 = R$. When $r > R$, the electric field force between the two charges is attractive for opposite charges and repulsive for like charges. When $r < R$, the electric field force between the two charges is repulsive for opposite charges and attractive for like charges. This is a characteristic of the electric field force that the Coulomb electric field force does not possess.

3、The nuclear force generated by the superposition of vacuum polarized charge clouds.

For over half a century, our understanding of the nuclear force between nucleons in the atomic nucleus has mainly come from experiments. Although quantum chromodynamics (QCD) can explain many nuclear phenomena theoretically, the study of the properties of the nuclear force between nucleons is still based on empirical phenomenological theories. It has not yet been directly derived from the mathematical expression of the nuclear force between two nucleons in the atomic nucleus by the theory of quantum chromodynamics. In particular, the repulsive force that exists between two nucleons at short distances has not been theoretically proven.

The author found that the nuclear force is also related to the positive and negative vacuum polarized charge clouds surrounding charged particles. When the interaction distance between two charged particles is small enough for the surrounding vacuum polarized charges to overlap, a nuclear force is generated between the two chargce, the termρin equation (17) is not zero, but rather given by equation

$$\rho = k^2 \varepsilon_0 V \mathrm{e}^{Rx} / q \tag{2 3}$$

where $k$is an undetermined constant. Therefore, equation (17) can be written as equation

$$\frac{d^2V}{dx^2} + 2R\frac{dV}{dx} + R^2V = k^2x^{-4}V \tag{24}$$

Solving this equation yields the potential energy of the nuclear force, given by equation

$$V = C_1\mathrm{e}^{-kr-R/r}/r + C_2\mathrm{e}^{kr-R/r}/r \tag{25}$$

where$r = 1/x$ and$R = \hbar/\mu c$. When $r >> R$, if it is equivalent to the potential energy of the Yukawa nuclear force,

$$V = -c\hbar e^{-kr}/r \tag{26}$$

the comparison of the two equations reveals that the constants and are related by equation

$$C_1 = -\hbar c\,, \quad C_2 = 0 \tag{27}$$

At $R \neq 0$Substituting these two constants into equation (25) yields the potential energy of the nuclear force at zero distance without divergence when

$$V = -c\hbar e^{-kr-R/r}/r \tag{28}$$

This leads to the derivation of the divergence-free nuclear force given by equation

$$\boldsymbol{F} = -\nabla V = -\frac{c\hbar}{r^3}\boldsymbol{r}\left(1 + kr - R/r\right)\mathrm{e}^{-kr-R/r} \tag{29}$$.

$F(r_0) = 0$, the nuclear force also has an equilibrium distancer_0, which is related to the equilibrium distance $R$of the electric field force according to equation

$$kr_0^{\ 2} + r_0 - R = 0 \tag{30}$$

When $r > r_0$, the nuclear force between two charges is attractive for like charges and repulsive for opposite charges, which is the opposite of the action of the electric field force. Figure 2 shows the variation curves of the Xiao's nuclear force and the Yukawa nuclear force between two protons, which can be calculated using equation (22) to obtain the integral constant $R = 0.42$fmand the equilibrium distance of the nuclear force $r_0 = 0.3$fm[11].

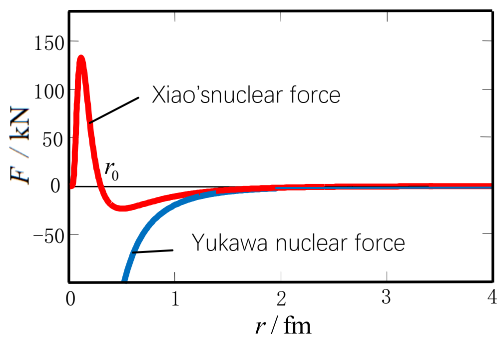


Fig. 2 Xiao's nuclear force and Yukawa nuclear force curves between p and q.

The nuclear force is also a type of electric field force, and the strength of the nuclear force $C_1$is related to the strength of the electric field force$e^2/4\pi\varepsilon_0$ through a Bose distribution function, as shown in equation

$$C_1 = -\alpha^{exp\,[-\bar{\eta}\,(R-r_0)]-1} e^2/4\pi\varepsilon_0 \tag{31}$$

where $\alpha = e^2/4\pi\varepsilon_0 c\hbar$ α and $\bar{\eta}$are undetermined constants. Substituting equation (31) and $C_2 = 0$ into equation (25), the potential energy of the nuclear force at zero distance can be written as equation

$$V = -\alpha^{\exp\left[-\bar{\eta}\left(R-r_0\right)\right]-1} e^2 \mathrm{e}^{-kr-R/r} / 4\pi\varepsilon_0 r \tag{32}$$

Which can be simplified to equation (28) in the case of $\bar{\eta}\left(R-r_0\right) >> 1$.

4、 Short-range weak force of the electric field

When the interaction distance between two charged particlesr_m is less than the maximum distance of the short-range weak force, a short-range weak force is generated between the two charged particles. Based on equation (17), it can be deduced whether $\rho = 0$the short-range weak force exists between two charged particles by determining whether is zero. There are two types of short-range weak forces between two charged particles.

4.1 Short-range weak electric force

When$\rho = 0$, in addition to obtaining the result of equation (20) from equation (17), another potential energy of the short-range weak electric force can be obtained when $x > x_m$, given by equation

$$V_{\mathrm{we}} = C_1 x \mathrm{e}^{-Rx} \int_{x_m}^{x} \mathrm{e}^{-\int_{x_m}^{x} 2R dx} \frac{dx}{\left(x\mathrm{e}^{-Rx}\right)^2} + C_2 \mathrm{e}^{-Rx}$$

$$= \frac{g_{we}}{r}\left(1 - r/r_m\right)\mathrm{e}^{R/r_m - R/r} + C_2 \mathrm{e}^{R/r_m - R/r} \tag{33}$$

where$g_{\mathrm{we}} = C_1 r_m e^{2R/r_m}$, the strength of the short-range weak electric force. $x = 1/r$,and $x_m = 1/r_m$,where is the maximum distance of the short-range weak electric force. C_1 and C_2 are undetermined constants.

The short-range weak electric force has a maximum distance of r_m. The constant $C_2 = g_{\mathrm{we}}/R$in equation (33) can be determined from $\nabla V_{\mathrm{we}} = -\frac{g_{\mathrm{we}}Rr}{r^4}(1 - r/r_m)$by the fact that the short-range weak force is zero at the maximum distance. Substituting this constant into equation (33) yields the $r_m$potential energy and force of the short-range weak electric force between two charges, given by equations

$$V_{\mathrm{we}} = \frac{g_{\mathrm{we}}}{r}\left(1 + r/R - r/r_m\right)\mathrm{e}^{R/r_m - R/r} \tag{34}$$

and

$$F_{\mathrm{we}} = -\nabla V_{\mathrm{we}} = -\frac{g_{\mathrm{we}}Rr}{r^4}(1 - r/r_m)e^{R/r_m - R/r} \quad (35),$$

when $r = r_m$respectively. It can be seen that when , the short-range weak electric force between two charges is zero; when $r < r_m$, the short-range weak electric force between two charges is attractive for like charges and repulsive for opposite charges; and when $r > r_m$, there is no short-range weak electric force.

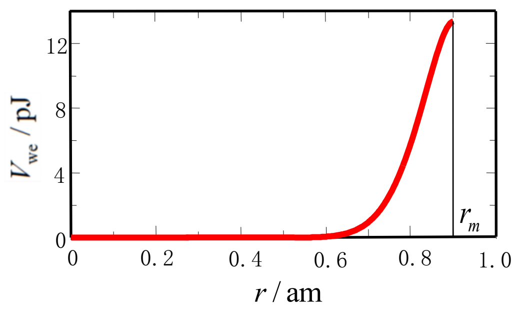


Fig.3 Potential energy curve of short range weak electric force

Figure 3 shows the potential energy curve of the short-range weak electric force when $r_m = 0.9\mathrm{am} = R/15$. At $r = r_m$, the potential energy of the short-range weak electric force has a maximum value of

$$V_{\mathrm{we}}\left(r_m\right) = g_{\mathrm{we}}\mathrm{e}^{R/r_m} / R \tag{36}$$

Based on the maximum distance $r_m$and the strength of the short-range weak force, it can be inferred that the relation of integral constant Rin the potential energy formula and the particles masses $M$and$m$is different from equation (22) and is given by equation

$$\begin{aligned} R &= \left(e^2 / 4\pi\varepsilon Mc^2 + GM / c^2\right) + \left(e^2 / 4\pi\varepsilon mc^2 + Gm / c^2\right) \\ &= \alpha\hbar / \mu c + G\left(M + m\right) / c^2 \end{aligned} \quad (37),$$

where $\mu = mM/(m + M)$, α is the fine structure constant.

The short-range weak force is also a type of electric field force, and its strength $g_{\mathrm{we}}$is related to the strength of the electric field force through a Fermi distribution function, as shown in equation

$$g_{\mathrm{we}} = \alpha^{\exp\left[-\bar{\eta}\left(R - r_0\right)\right] + 1} e^2 / 4\pi\varepsilon_0 \quad (38),$$

where and are undetermined constants. Substituting equation (38) into equation (34) yields the potential energy of the short-range weak electric force, given by equation

$$V_{\mathrm{we}}=\alpha^{\exp\left[-\bar{\eta}\left(R-r_0\right)\right]+1}\frac{e^2}{4\pi\varepsilon_0 r}\left(1+r/R-r/r_m\right)\mathrm{e}^{-R/r} \tag{39},$$

whichcan be simplified to the following equation when $\bar{\eta}(R-r_0)>>1$

$$\begin{aligned}V_{\mathrm{we}}&=\alpha\frac{e^2}{4\pi\varepsilon_0 r}\left(1+r/R-r/r_m\right)\mathrm{e}^{-R/r}\\&=\alpha^2\frac{c\hbar}{r}\left(1+r/R-r/r_m\right)\mathrm{e}^{-R/r}\end{aligned} \tag{40}$$

4.2 Short-range weak nuclear force

For $\rho\neq 0$, in addition to obtaining the result of equation (28) from equation (17), another potential energy of the short-range weak nuclear force can be obtained when $x>x_m$, given by equation

$$\begin{aligned}V_{\mathrm{ws}}&=C_1 x\mathrm{e}^{-k/x-Rx}\int_{x_m}^{x}\mathrm{e}^{-\int_{x_m}^{x}2R dx}\frac{dx}{\left(x\mathrm{e}^{-k/x-Rx}\right)^2}+C_2\mathrm{e}^{-Rx}\\&=g_{\mathrm{ws}}\left(1-\mathrm{e}^{-2k\left(r_m-r\right)}\right)\mathrm{e}^{-kr-R/r}/r+C_2\mathrm{e}^{-R/r}\end{aligned} \tag{41}$$

where $g_{\mathrm{ws}}=C_1\mathrm{e}^{2\left(kr_m+R/r_m\right)}/2k$. The constant $C_2=2kr_m g_{\mathrm{ws}}e^{-kr_m}/R$can be derived from $\nabla V_{\mathrm{ws}}(r_m)=0$, and equation (41) can be rewritten as equation

$$V_{\mathrm{ws}}=2g_{\mathrm{ws}}\left(kr_m r/R+\sinh\delta\right)\mathrm{e}^{-kr_m-R/r}/r \tag{42}$$

where $\delta=k\left(r_m-r\right)$. At $r=r_m$, the potential energy of the short-range weak nuclear force has a maximum value of .

$$V_{\mathrm{ws}}\left(r_m\right)=2kr_m g_{\mathrm{ws}}\mathrm{e}^{-kr_m-R/r_m}/R \tag{43}$$

Experimental observations have shown that all weak interaction strengths are equal [12], such as β、π—μ、μ—e, decay, μ capture, and related strange particle decays. Without exception, they all have approximately the same strength. This means that both the short-range weak electric force and the short-range weak nuclear force have the same potential energy at the maximum distance r_m of the force, given by equation

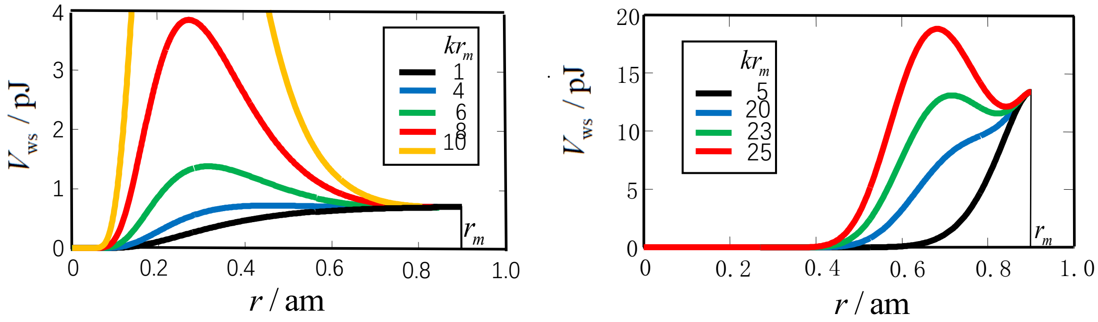
$$V_{\mathrm{ws}}\left(r_m\right)=V_{\mathrm{we}}\left(r_m\right) \tag{44}$$

Substituting equations (36) and (43) into equation (44) reveals equation

$$g_{\mathrm{ws}}=g_{\mathrm{we}}e^{kr_m}/2kr_m \tag{45}$$

. Substituting equation (45) into equation (42) yields the potential energy of the short-range weak nuclear force, given by equation

$$V_{\mathrm{ws}} = g_{\mathrm{we}}\left(r / R + \sinh\delta / kr_m\right) e^{-R/r} / r \tag{46}$$



(a) $r_m = 0.9\mathrm{am} = R$　　(b) $r_m = 0.9\mathrm{am} = R/15$

Fig.4 .Potential energy curve of short range weak nuclear force action

Figure 4 shows kr_m the potential energy curves of the weak nuclear force for differentvalues of , where Figure 4(a) showsthe curves for when $r_m = 0.9_{\mathrm{am}=}R$ and kr_m= 1, 4, 6, 8. Figure 4(b) showsthe curves for when $r_m = 0.9\mathrm{am}{=}R/15$ and are kr_m= 5, 20, 23, 25. It can be observed from the two figures that when $r_m << R$ the potential energy of the short-range weak nuclear force has two maximum values, indicating that the short-range weak nuclear force also exhibits attractive and repulsive changes with distance.

Utilizing $\mathbf{F}_{ws} = -\nabla V_{ws}$, we can obtain short-range weak nuclear force

$$\boldsymbol{F}_{\mathrm{ws}} = -\frac{g_{\mathrm{we}}\boldsymbol{r}}{r^3}\left(1 + \frac{R-r}{kr_m r}\sinh\delta - \frac{r}{r_m}\cosh\delta\right)e^{-r_m/r} \tag{47}$$

When $r = r_m$, the short-range weak nuclear force is zero; when $r < r_m$, the short-range weak nuclear force is attractive for two charges with the same sign and repulsive for charges with opposite signs; when $r > r_m$, there is no short-range weak nuclear force, which is similar to the behavior of short-range electroweak force.

5、Universal Gravitation under the Influence of Complex Charges

The study of the unification of universal gravitation and electromagnetic force is a hot topic in theoretical physics [13,14]. The author found that positive and negative charges can be represented as complex quantities. By multiplying these complex charges, it can be concluded that the attractive force between charges with opposite signs is slightly greater than the repulsive force between charges with the same sign. Therefore, even in neutral matter without net charge, there exists residual electric field attraction, which is Newton's universal gravitation.

In a source-free space, the electric potential Q_0 of the electric field excited by charge φ satisfies the Laplace's equation $\nabla^2\varphi = 0$. By using the two-dimensional plane where the action distance r is located, a canonical function with the electric potential φ as itsmaginary part can be obtained.

$$f(z) = \psi + i\varphi \tag{48}$$

where $i = \sqrt{-1}$. The force components at point z are $-d\varphi/dx$, $-d\varphi/dy$, and therefore the magnitude is

$$E = \sqrt{\left(\frac{\partial\varphi}{\partial x}\right)^2 + \left(\frac{\partial\varphi}{\partial y}\right)^2} = \sqrt{\left(\frac{\partial\psi}{\partial x}\right)^2 + \left(\frac{\partial\varphi}{\partial x}\right)^2} = \left|\frac{df(z)}{dz}\right| \tag{49}$$

By using $z = r\mathbf{e}^{-i\phi}$, the force X can be transformed into the plane where $r = \sqrt{x^2 + y^2}$ is located, where ϕ is a constant, i.e.,

$$E = \left|\frac{df(z)}{dr}\frac{dr}{dz}\right| = \left|\frac{d\psi}{dr}\mathrm{e}^{i\phi} + i\frac{d\varphi}{dr}\mathrm{e}^{i\phi}\right| \tag{50}$$

Taking the constant ϕ equal to $\boldsymbol{k}_0 \cdot \boldsymbol{r}_0\phi_0$, where $\boldsymbol{r}_0 = \boldsymbol{r}/r$, ϕ_0 is an undetermined constant, and $\boldsymbol{k}_0$ is the direction vector of the electric Q_0 field lines of charge. The right side of equation (50) is the complex potential $\varphi\mathrm{e}^{i\phi}$ of the radial electric field.

$$\varphi' = \varphi\mathrm{e}^{i\phi} = Q/4\pi\varepsilon_0 r \tag{51}$$

where $Q = Q_0\, e^{ik_0\cdot r_0\phi_0}$. From this, it can be inferred that the acting charges can also be represented as complex quantities. By multiplying these two complex charges, it can be found that, under the same charge condition, the repulsive force between charges with the same sign is slightly smaller than the attractive force between charges with opposite signs. This means that even in neutral matter without net charge, there exists electric field attraction, and it can be proven that this electric field attraction is the universal gravitation proportional to the product of the masses of the two neutral substances.

The potential energy of charge q under the action of charge Q should be the real part of the product of these two complex charges, as known from (20):

$$V = \mathrm{Re}\left[q^*\varphi'\right]\mathrm{e}^{-R/r} = \cos\left[\left(\boldsymbol{k}_0 - \boldsymbol{k}_0'\right)\cdot \boldsymbol{r}_0\phi_0\right]\frac{q_0 Q_0}{4\pi\varepsilon_0 r}\mathrm{e}^{-R/r} \tag{52}$$

where $q = q_0\,\mathrm{e}^{i\boldsymbol{k}_0'\cdot \boldsymbol{r}_0\phi_0}$, $\boldsymbol{k}_0'$ is the direction vector of charge q_0, Re [ ] represents the real part, and * denotes the complex conjugate of q.

According to the convention that the direction of electric field lines of positive charges is away from the charge and the direction of electric field lines of negative charges is towards the charge, when Q_0 and q_0 have charges with the same sign, as shown in Figure 5(a), the direction of electric field lines $\boldsymbol{k}_0'$ is opposite to $\boldsymbol{k}_0$, so $(k_0 - k_0')\cdot r_0 = 2$; when Q_0 and q_0 have charges with opposite signs, as shown in Figure 5(b), the direction of electric field lines $\boldsymbol{k}_0'$ is the same as $\boldsymbol{k}_0$, so $(k_0 -$

$k_0) \cdot r_0 = 0$. Thus, according to (52), the potential energy of static interaction between two charges with the same sign is

$$V_{same} = cos(2\phi_0)\,|q_0Q_0|e^{-R/r}/4\pi\varepsilon_0 r \tag{53}$$

and the potential energy of static interaction between two charges with opposite signs is

$$V_{opps} = -|q_0Q_0|e^{-R/r}/4\pi\varepsilon_0 r \tag{54}$$

It can be seen that as long as $\phi_0 \neq 0$, it is always $|V_{opps}| > |V_{same}|$. This means that even in neutral matter without net charge, there exists electric field attraction, and Newton's universal gravitation is the manifestation of this static residual electric field force.

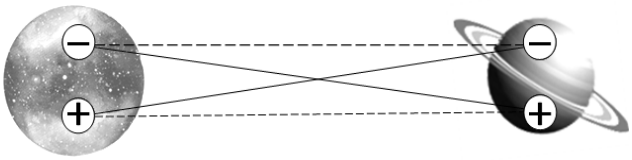
(a) (b)

Figure 5. Direction relation of electric power lines between two acting charges

Matter is composed of protons, neutrons, and electrons as fundamental particles. Protons carry a unit positive charge, electrons carry a unit negative charge, and neutrons have no charge. Moreover, the number of protons in neutral matter is always equal to the number of electrons it contains. If neutrons are considered as fundamental particles carrying equal amounts of positive and negative charges, as shown in Figure 6, the total potential energy of static interaction between two neutral substances can be observed as

$$V = 2(V_{opps} + V_{sam}) \tag{55}$$

If the mass of M -neutral object carries positive and negative charges of Q_0 units each q_0, $M$and $m$the mass of -neutral object carries positive and negative charges of X units each,



The attractive force The repulsive force

Figure 6. Diagram of electrostatic interaction between two neutral substances

The total potential energy of static interaction between V_{opps} and V_{sam} can be calculated separately using equations (54) and (53), and by substituting these two equations into (55), the total potential energy of static interaction between two neutral objects can be obtained as

$$V = -2(1-\cos 2\phi_0)|q_0Q_0|\mathrm{e}^{-R/r}/4\pi\varepsilon_0 r = -\sin^2\phi_0|q_0Q_0|\mathrm{e}^{-R/r}/\pi\varepsilon_0 r \tag{56}$$

Q_0 and q_0 can be resolved by the following way: let $\bar{M}$ represents the molar mass of the neutral substance's atomic nucleus and N_0 represents Avogadro's constant, and $N_0/\bar{M}$ represents the total number of atomic nuclei in a unit mass of neutral substance. Therefore, the total number of atomic nuclei in a neutral substance with mass M is $MN_0/\bar{M}$. Since each atomic nucleus carries $\bar{M}$ nucleons (protons and neutrons), the total number of nucleons in a neutral substance with mass M is

$$n=\left(MN_0/\bar{M}\right)\bar{M}=MN_0 \tag{57}$$

where each proton and neutron carries a unit positive charge $+e$, and each neutron carries a unit negative charge $-e$. Therefore, the total number of positive and negative charges in a neutral substance with mass M is equal to the total number of nucleons, and M the total positive and negative charges are

$$|+Q_0|=|-Q_0|=n|e|=MN_0|e| \tag{58}$$

Similarly, it can be known that the total positive and negative charges in a neutral substance with mass m are

$$|+q_0|=|-q_0|=mN_0|e| \tag{59}$$

By substituting equations (58) and (59) into (58), the gravitational potential energy between two neutral objects with masses M and m can be obtained as

$$V=-N_0^2|e|^2\sin^2\phi_0 Mm\mathrm{e}^{-R/r}/\pi\varepsilon_0 r=-GMm\mathrm{e}^{-R/r}/r \tag{60}$$

where $G=N_0^2|e|^2\sin^2\phi_0/\pi\varepsilon_0$. The corresponding gravitational force is

$$\boldsymbol{F}=-\nabla V=-GMm\left(1-R/r\right)\mathrm{e}^{-R/r}\boldsymbol{r}/r^3 \tag{61}$$

It can be seen that there is also an equilibrium distance for the universal gravitation between two neutral substances. When $r=R$, the force is zero; when $r<R$, the force is repulsive; when $r>R$, the force is attractive. Newton's universal gravitation is the result when $r>>R$.

If we let

$$, \quad M^*=M\,\mathrm{e}^{-GM/rc^2}, \quad m^*=m\,\mathrm{e}^{-Gm/rc^2} \tag{62}$$

the potential energy of universal gravitation given by equation (60) can also be written as

$$V=-GM^*m^*/r \tag{63}$$

From this, it can be seen that universal gravitation can also be expressed in the form of

$$\boldsymbol{F}=-\nabla V=m^*\boldsymbol{g}+GM^*\nabla m^*/r \tag{64}$$

where $\boldsymbol{g}=\nabla\left(GM^*/r\right)$. The inertial force experienced by an object under the influence of gravitational force is

$$\boldsymbol{F}_{惯}=\boldsymbol{F}-GM^*\nabla m^*/r=m^*\boldsymbol{g} \tag{65}$$

6、 Conclusion

Based on the fact that there are positive and negative vacuum polarization charge clouds around all charged particles, this paper proposes that the vacuum polarization charge clouds have additional effects on the surrounded charges. By considering these additional effects, the electric field potential energy between two charges derived from the divergence equation of the electric field satisfies a constant-coefficient linear second-order differential equation.

$$\frac{d^2V}{dx^2}+2R\frac{dV}{dx}+R^2V=-x^{-4}\mathrm{e}^{-Rx}q\rho/\varepsilon_0$$

This is the desired equation that unifies the four field forces. The homogeneous linear equation has a solution of long-range electric field force without divergence at zero distance. The non-homogeneous linear equation has two independent solutions, which are the nuclear force potential energy without divergence at zero distance and the short-range weak force potential energy. This paper also proposes the asymmetry of charge interaction, where the repulsive force between charges with the same sign is slightly smaller than the attractive force between charges with opposite signs. This leads to the presence of electric field attraction between two neutral substances even without net charge, and it is demonstrated that this electric field attraction is universal gravitation proportional to the product of the masses of the two neutral substances. Furthermore, from the intensities of the four field forces:

Electric field force $qQ/4\pi\varepsilon_0=Z_1Z_2\,e^2/4\pi\varepsilon_0$

Nuclear force $c\hbar=\alpha^{\exp\left[-\bar{\eta}\left(R-r_0\right)\right]-1}e^2/4\pi\varepsilon_0$

Short-range weak force $\alpha^2c\hbar=\alpha^{\exp\left[-\bar{\eta}\left(R-r_0\right)\right]+1}e^2/4\pi\varepsilon_0$

Universal gravitation $GMm=4N_0{}^2Mm\sin^2\phi_0e^2/4\pi\varepsilon_0$

it can be seen that all four field forces originate from the interaction between charges. Charges are not only the source of electric field force but also the source of nuclear force, short-range weak force, and universal gravitation. Without the existence of positive and negative charges, the four field forces do not exist.

The biggest flaw in using the electric field force theory to establish a unified theory of the four field forces is that it is too intuitive and simple. However, the creator of the world is an "old man" with billions of years of experience. Compared to the complex and uncertain "rules of the game," he may prefer the former.

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