Fundamental Elements and Interactions of Nature: A Classical Unification Theory

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A classical unification theory that completely unifies all the fundamental interactions of nature is developed. First, the nature is suggested to be composed of the following four fundamental elements: mass, radiation, electric charge, and color charge. All known types of matter or particles are a combination of one or more of the four fundamental elements. Photons are radiation; neutrons have only mass; protons have both mass and electric charge; and quarks contain mass, electric charge, and color charge. The nature fundamental interactions are interactions among these nature fundamental elements. Mass and radiation are two forms of real energy. Electric and color charges are considered as two forms of imaginary energy. All the fundamental interactions of nature are therefore unified as a single interaction between complex energies. The interaction between real energies is the gravitational force, which has three types: mass-mass, mass-radiation, and radiation-radiation interactions. Calculating the work done by the mass-radiation interaction on a photon derives the Einsteinian gravitational redshift. Calculating the work done on a photon by the radiation-radiation interaction derives a radiation redshift, which is much smaller than the gravitational redshift. The interaction between imaginary energies is the electromagnetic (between electric charges), weak (between electric and color charges), and strong (between color charges) interactions. In addition, we have four imaginary forces between real and imaginary energies, which are mass-electric charge, radiation-electric charge, mass-color charge, and radiation-color charge interactions. Among the four fundamental elements, there are ten (six real and four imaginary) fundamental interactions. This classical unification theory deepens our understanding of the nature fundamental elements and interactions, develops a new concept of imaginary energy for electric and color charges, and provides a possible source of energy for the origin of the universe from nothing to the real world.

1 Introduction

In the ancient times, the nature was ever considered to have five elements: space, wind, water, fire, and earth. In traditional Chinese Wu Xing (or five-element) theory, the space and wind are replaced by metal and wood. All the natural phenomena are described by the interactions of the five elements. There are two cycles of balances: generating (or sheng in Chinese) and overcoming (or ke in Chinese) cycles. The generating cycle includes that wood feeds fire, fire creates earth (or ash), earth bears metal, metal carries water, and water nourishes wood; while the overcoming cycle includes that wood parts earth, earth absorbs water, water quenches fire, fire melts metal, and metal chops wood.

According to the modern scientific view, how many elements does the nature have? How do these fundamental elements interact with each other? It is well known that there have been four fundamental interactions found in the nature. They are the gravitational, electromagnetic, weak, and strong interactions. The gravitational interaction is an interaction between masses. The electromagnetic interaction is an interaction between electric charges. The strong interaction is an interaction between color charges. What is the weak interaction? Elementary particles are usually classified into two categories: hadrons and leptons. Hadrons participate in both strong and weak interactions, but leptons can only participate in the weak interaction. If the weak interaction is an interaction between weak charges, what is the weak charge? How many types of weak changes? Are the weak charges in hadrons different from those in leptons? Do we really need weak charges for the weak interaction? All of these are still unclear although the weak interaction has been extensively investigated for many decades. Some studies of particular particles show that the weak charges might be proportional to electric charges.

In this paper, we suggest that the nature has four fundamental elements, which are: mass M, radiation γ, electric charge Q, and color charge C. Any type of matter or particle contains one or more of these four elements. For instances, a neutron has mass only; a photon is just a type of radiation, which is massless; a proton contains both mass and electric charge; and a quark combines mass, electric charge, and color charge together. Mass and radiation are well understood as two forms of real energy. Electric charge is a property of some elementary particles such as electrons and protons and has two varieties: positive and negative. Color charge is a property of quarks, which are sub-particles of hadrons, and has three varieties: red, green, and blue. The nature fundamental interactions are the forces among these fundamental elements. The weak interaction is considered as an interaction between color charges and electric charges.

Recently, Zhang has considered the electric charge to be a form of imaginary energy [1]. With this consideration, the energy of an electrically charged particle is a complex number. The real part is proportional to the mass as the Einsteinian mass-energy expression represents, while the imaginary part is proportional to the electric charge. The energy of an antiparticle is given by conjugating the energy of its corresponding particle. Newton's law of gravity and Coulomb's law of electric force were classically unified into a single expression of the interaction between the complex energies of two electrically charged particles. Interaction between real energies (including both mass and radiation) is the gravitational force, which has three types: mass-mass, mass-radiation, and radiation-radiation interactions. Calculating the work done by the mass-radiation interaction on a photon, we derived the Einsteinian gravitational redshift. Calculating the work done by the radiation-radiation interaction on a photon, we obtained a radiation redshift, which is negligible in comparison with the gravitational redshift. Interaction between imaginary energies (or between electric charges) is the electromagnetic force.

In this study, we further consider the color charge to be another form of imaginary energy. Therefore, the nature is a system of complex energy and the four fundamental elements of nature are described as a complex energy. The real part includes the mass and radiation, while the imaginary part includes the electric and color charges. All the fundamental interactions can be classically unified into a single interaction between complex energies. The interaction between real energies is gravitational interaction. By including the massless radiation, we have three types of gravitational forces. The interaction between imaginary energies are electromagnetic (between electric charges), weak (between electric and color charges), and strong (between color charges) interactions. In addition, we have four types of imaginary forces (between real and imaginary energies): mass-electric charge interaction, radiation-electric charge interaction, mass-color charge interaction, and radiation-color charge interaction. Among the four fundamental elements, we have in total ten (six real and four imaginary) fundamental interactions.

2 Fundamental elements of Nature

2.1 Mass — a form of real energy

It is well known that mass is a fundamental property of matter, which directly determines the gravitational interaction via Newton's law of gravity [2]. Mass M is a quantity of matter [3], and the inertia of motion is solely dependent upon mass [4]. A body experiences an inertial force when it accelerates relative to the center of mass of the entire universe. In short, mass there affects inertia here.

According to Einstein's energy-mass expression (or Einstein's first law) [5], mass is also understood as a form of real energy. A rest object or particle with mass M has real energy given by

$$E^M = Mc^2, \tag{1}$$

where c is the speed of light. The real energy is always positive. It cannot be destroyed or created but can be transferred from one form to another.

2.2 Radiation — a form of real energy

Radiation γ refers to the electromagnetic radiation (or light). In the quantum physics, radiation is described as radiation photons, which are massless quanta of real energy [6]. The energy of a photon is given by

$$E^\gamma = h\nu, \tag{2}$$

where $h = 6.6{\times}10^{-34}$ J·s is the Planck constant [7] and ν is the radiation frequency from low frequency (e.g., 10^3 Hz) radio waves to high frequency (e.g., 10^{20} Hz) γ-rays. Therefore, we can generally say that the radiation is also a form of real energy.

2.3 Electric charge — a form of imaginary energy

Electric charge is another fundamental property of matter, which directly determines the electromagnetic interaction via Coulomb's law of electric force [8], which is generalized to the Lorentz force expression for moving charged particles. Electric charge has two varieties of either positive or negative. It appears or is observed always in association with mass to form positive or negative electrically charged particles with different amount of masses. The interaction between electric charges, however, is completely independent of mass. Positive and negative charges can annihilate or cancel each other and produce in pair with the total electric charges conserved. Therefore, electric charge should have its own meaning of physics.

Recently, Zhang has considered the electric charge Q to be a form of imaginary energy [1]. The amount of imaginary energy is defined as

$$E^Q = \frac{Q}{\sqrt{G}}c^2, \tag{3}$$

where G is the gravitational constant. The imaginary energy has the same sign as the electric charge. Then, for an electrically charged particle, the total energy is

$$E = E^M + iE^Q = (1 + i\alpha)Mc^2. \tag{4}$$

Here, $i = \sqrt{-1}$ is the imaginary number, α is the charge-mass ratio defined by

$$\alpha = \frac{Q}{\sqrt{G}M}, \tag{5}$$

in the cgs unit system. Including the electric charge, we have modified Einstein's first law Eq. (1) into Eq. (4). In other words, electric charge is represented as an imaginary mass. For an electrically charged particle, the absolute value of α is a big number. For instance, proton's α is about 10^{18} and electron's α is about $-2{\times}10^{21}$. Therefore, an electrically charged particle holds a large amount of imaginary energy in comparison with its real or rest energy. A neutral particle such as a neutron, photon, or neutrino has only a real energy. Weinberg suggested that electric charges come from the fifth-dimension [9], a compact circle space in the Kaluza-Klein theory [10–12]. Zhang has shown that electric charge can affect light and gravity [13].

The energy of an antiparticle [14, 15] is naturally obtained by conjugating the energy of the corresponding particle [1]

$$E^* = \left(E^M + iE^Q\right)^* = E^M - iE^Q. \qquad (6)$$

The only difference between a particle and its corresponding antiparticle is that their imaginary energies (thus their electric charges) have opposite signs. A particle and its antiparticle have the same real energy but have the sign-opposite imaginary energy. In a particle-antiparticle annihilation process, their real energies completely transfer into radiation photon energies and their imaginary energies annihilate or cancel each other. Since there are no masses to adhere, the electric charges come together due to the electric attraction and cancel each other (or form a positive-negative electric charge pair $(+, -)$). In a particle-antiparticle pair production process, the radiation photon energies transfer to rest energies with a pair of imaginary energies, which combine with the rest energies to form a particle and an antiparticle.

To describe the energies of all particles and antiparticles, we can introduce a two-dimensional energy space. It is a complex space with two axes denoted by the real energy E^M and the imaginary energy iE^Q. There are two phases in this two-dimensional energy space because the real energy is positive. In phase I, both real and imaginary energies are positive, while, in phase II, the imaginary energy is negative. Neutral particles including massless radiation photons are located on the real energy axis. Electrically charged particles are distributed between the real and imaginary energy axes. A particle and its antiparticle cannot be located in the same phase of the energy space. They distribute in two phases symmetrically with respect to the real energy axis.

The imaginary energy is quantized because the electric charge is so. Each electric charge quantum e has the following imaginary energy $E_e = ec^2/\sqrt{G} \sim 10^{27}$ eV, which is about 10^{18} times greater than proton's real energy (or the energy of proton's mass). Dividing the size of proton by the imaginary-real energy ratio (10^{18}), we obtain a scale length $l_Q = 10^{-33}$ cm, the size of the fifth-dimension in the Kaluza-Klein theory. In addition, this amount of energy is equivalent to a temperature $T = 2E_e/k_B \sim 2.4{\times}10^{31}$K with k_B the Boltzmann constant. In the epoch of big bang, the universe could reach this high temperature. Therefore, big bang of the universe from nothing to a real world, if really occured, might be a process that transfers a certain amount of imaginary energy to real energy. In the recently proposed black hole universe model, however, the imaginary-real energy transformation could not occur because of low temperature [16].

Names	Symbols	Masses	Electric Charge (e)
up	u	2.4 MeV	2/3
down	d	4.8 MeV	−1/3
charm	c	1.27 GeV	2/3
strange	s	104 MeV	−1/3
top	t	171.2 GeV	2/3
bottom	b	4.2 GeV	−1/3

Table 1: Properties of quarks: names, symbols, masses, and electric charges.

2.4 Color charge — a form of imaginary energy

In the particle physics, all elementary particles can be categorized into two types: hadrons and leptons, in accord with whether they experience the strong interaction or not. Hadrons participate in the strong interaction, while leptons do not. All hadrons are composed of quarks. There are six types of quarks denoted as six different flavors: up, down, charm, strange, top, and bottom. The basic properties of these six quarks are shown in Table 1.

Color charge (denoted by C) is a fundamental property of quarks [17], which has analogies with the notion of electric charge of particles. There are three varieties of color charges: red, green, and blue. An antiquark's color is antired, antigreen, or antiblue. Quarks and antiquarks also hold electric charges but the amount of electric charges are frational such as $\pm e/3$ or $\pm 2e/3$. An elementary particle is usually composed by two or more quarks or antiquarks and colorless with electric charge to be a multiple of e. For instance, a proton is composed by two up quarks and one down quarks (uud); a neutron is composed by one up quark and two down quarks (udd); a pion, π^+, is composed by one up quark and one down antiquark ($u\bar{d}$); a charmed sigma, Σ_c^{++}, is composed by two up quarks and one charm quark ($uu\bar{c}$); and so on.

Similar to electric charge Q, we can consider color charge C to be another form of imaginary energy. The amount of imaginary energy can be defined by

$$E^C = \frac{C}{\sqrt{G}}\, c^2. \qquad (7)$$

Then, for a quark with mass M, electric charge Q, and color charge C, the total energy of the quark is

$$E = E^M + iE^Q + iE^C = \left[1 + i(\alpha + \beta)\right] Mc^2, \qquad (8)$$

where β is given by

$$\beta = \frac{C}{\sqrt{G}M}\,. \qquad (9)$$

The total energy of a quark is a complex number.

The energy of an antiquark is naturally obtained by conjugating the energy of the corresponding quark

$$E^* = \left(E^M + iE^Q + iE^C\right)^* = E^M - iE^Q - iE^C = \\ = \left[1 - i(\alpha + \beta)\right] Mc^2. \quad (10)$$

The only difference between a quark and its corresponding antiquark is that their imaginary energies (thus their electric and color charges) have opposite signs. A quark and its antiquark have the same real energy and equal amount of imaginary energy but their signs are opposite. The opposite of the red, green, and blue charges are antired, antigreen, and antiblue charges.

To describe the energies of all particles and antiparticles including quarks and antiquarks, we can introduce a three-dimensional energy space. It is a complex space with three axes denoted by the real energy E^M, the electric imaginary energy iE^Q, and the color imaginary energy iE^C. There are four phases in this three-dimensional energy space. In phase I, all real and imaginary energies are positive; in phase II, the imaginary energy of electric charge is negative; in phase III, the imaginary energies of both electric and color charges are negative; and in phase IV, the imaginary energy of color charge is negative. Neutral particles including massless radiation photons are located on the real-energy axis. Electrically charged particles are distributed on the plane composed of the real-energy axis and the electric charge imaginary-energy axis. Quarks are distributed in all four phases. Particles and their antiparticles are distributed on the plane of the real-energy axis and the electric charge imaginary-energy axis symmetrically with respect to the real-energy axis. Quarks and their antiquarks are distributed in different phases by symmetrically with respect to the real-energy axis and separated by the plane of the real and electric imaginary energy axes.

3 Fundamental interactions of Nature

Fundamental interactions of nature are all possible interactions between the four fundamental elements of nature. Each of the four fundamental elements is a form of energy (either real or imaginary), the fundamental interactions can be unified as a single interaction between complex energies given by

$$\vec{F}_{EE} = -G\,\frac{E_1 E_2}{c^4 r^2}\,\hat{r}, \quad (11)$$

where E_1 and E_2 are the complex energy given by

$$E_1 = E_1^M + E_1^\gamma + i\left(E_1^Q + E_1^C\right), \quad (12)$$

$$E_2 = E_2^M + E_2^\gamma + i\left(E_2^Q + E_2^C\right). \quad (13)$$

Replacing E_1 and E_2 by using the energy expression (12) and (13), we obtain

$$\vec{F}_{EE} = \vec{F}_{RR} + \vec{F}_{II} + i\vec{F}_{RI} =$$

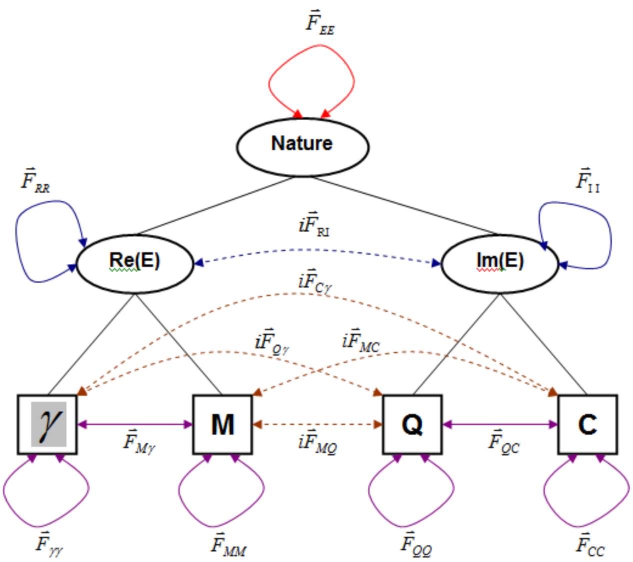

Fig. 1: Fundamental interactions among four fundamental elements of nature: mass, radiation, electric charge and color charge. Mass and radiation are real energies, while electric and color charges are imaginary energies. The nature is a system of complex energy and all the fundamental interactions of nature are classically unified into a single interaction between complex energies. There are six real and four imaginary interactions among the four fundamental elements.

$$= -G\,\frac{M_1 M_2}{r^2}\,\hat{r} - G\,\frac{M_1 h\nu_2 + M_2 h\nu_1}{c^2 r^2}\,\hat{r} - G\,\frac{h\nu_1 h\nu_2}{c^4 r^2}\,\hat{r} + \\ + \frac{Q_1 Q_2}{r^2}\,\hat{r} + \frac{Q_1 C_2 + Q_2 C_1}{r^2}\,\hat{r} + \frac{C_1 C_2}{r^2}\,\hat{r} - \\ - i\sqrt{G}\,\frac{M_1 Q_2 + M_2 Q_1}{r^2}\,\hat{r} - i\sqrt{G}\,\frac{M_1 C_2 + M_2 C_1}{r^2}\,\hat{r} - \\ - i\sqrt{G}\,\frac{h\nu_1 Q_2 + h\nu_2 Q_1}{c^2 r^2}\,\hat{r} - i\sqrt{G}\,\frac{h\nu_1 C_2 + h\nu_2 C_1}{c^2 r^2}\,\hat{r} \equiv \\ \equiv \vec{F}_{MM} + \vec{F}_{M\gamma} + \vec{F}_{\gamma\gamma} + \vec{F}_{QQ} + \vec{F}_{QC} + \vec{F}_{CC} + \\ + i\vec{F}_{MQ} + i\vec{F}_{MC} + i\vec{F}_{Q\gamma} + i\vec{F}_{C\gamma}\,. \quad (14)$$

It is seen that the interaction between complex energies $\vec{F}_{EE}$ is decoupled into the real-real energy interaction $\vec{F}_{RR}$, the imaginary-imaginary energy interaction $\vec{F}_{II}$, and the real-imaginary energy interaction $i\vec{F}_{RI}$. The real-real energy interaction $\vec{F}_{RR}$ is decoupled into the mass-mass interaction $\vec{F}_{MM}$, the radiation-radiation interaction $\vec{F}_{\gamma\gamma}$, and the mass-radiation interaction $\vec{F}_{M\gamma}$. The imaginary-imaginary energy interaction $\vec{F}_{II}$ is decoupled into the interaction between electric charges $\vec{F}_{QQ}$, the interaction between color charges $\vec{F}_{CC}$, and the interaction between electric and color charges $\vec{F}_{QC}$. The real-imaginary energy interaction $i\vec{F}_{RI}$ is decoupled into the mass-electric charge interaction $i\vec{F}_{MQ}$, the mass-color charge interaction $i\vec{F}_{MC}$, the radiation-electric charge interaction $i\vec{F}_{Q\gamma}$, the radiation-color charge interaction $i\vec{F}_{C\gamma}$. All these interactions as shown in Eq. (14) can be represented by Figure 1 or Table 2.

	M	γ	iQ	iC
M	$\vec{F}_{\mathrm{MM}}$	$\vec{F}_{\mathrm{M}\gamma}$	$i\vec{F}_{\mathrm{MQ}}$	$i\vec{F}_{\mathrm{MC}}$
γ		$\vec{F}_{\gamma\gamma}$	$i\vec{F}_{\mathrm{Q}\gamma}$	$i\vec{F}_{\mathrm{C}\gamma}$
iQ			$\vec{F}_{\mathrm{QQ}}$	$\vec{F}_{\mathrm{QC}}$
iC				$\vec{F}_{\mathrm{CC}}$

Table 2: Fundamental elements and interactions of nature.

3.1 Gravitational force

The force $\vec{F}_{MM}$ represents Newton's law for the gravitational interaction between two masses. This force governs the orbital motion of the solar system. The force $\vec{F}_{M\gamma}$ is the gravitational interaction between mass and radiation. The force $\vec{F}_{\gamma\gamma}$ is the gravitational interaction between radiation and radiation. These three types of gravitational interactions are categorized from the interaction between real energies (see Figure 3 of [1]).

Calculating the work done by this mass-radiation force on a photon, we can derive the Einsteinian gravitational redshift without using the Einsteinian general relativity

$$Z_G = \frac{\lambda_o - \lambda_e}{\lambda_e} = \exp\left(\frac{GM}{c^2 R}\right) - 1. \tag{15}$$

In the weak field approximation, it reduces

$$Z_G \simeq \frac{GM}{c^2 R}\,. \tag{16}$$

Similarly, calculating the work done on a photon from an object by the radiation-radiation gravitation $\vec{F}_{\gamma\gamma}$, we obtain a radiation redshift,

$$Z_\gamma = \frac{4GM}{15c^5}\,\sigma A T_c^4 + \frac{G}{c^5}\,\sigma A T_s^4, \tag{17}$$

where σ is the Stepan-Boltzmann constant, A is the surface area, T_c is the temperature at the center, T_s is the temperature on the surface. Here we have assumed that the inside temperature linearly decreases from the center to the surface. The radiation redshift contains two parts. The first term is contributed by the inside radiation. The other is contributed by the outside radiation. The redshift contributed by the outside radiation is negligible because $T_s \ll T_c$.

The radiation redshift derived here is significantly small in comparison with the empirical expression of radiation redshift proposed by Finlay-Freundlich [18]. For the Sun with $T_c = 1.5{\times}10^7$ K and $T_s = 6{\times}10^3$ K, the radiation redshift is only about $Z_\gamma = 1.3{\times}10^{-13}$, which is much smaller than the gravitational redshift $Z_G = 2.1{\times}10^{-6}$.

3.2 Electromagnetic force

The force $\vec{F}_{QQ}$ represents Coulomb's law for the electromagnetic interaction between two electric charges. Electric charges have two varieties and thus three types of interactions: 1) repelling between positive electric charges $\vec{F}_{++}$, 2) repelling between negative electric charges $\vec{F}_{--}$, and 3) attracting between positive and negative electric charges $\vec{F}_{+-}$. Figure 2 of [1] shows the three types of Coulomb interactions between two electric charges.

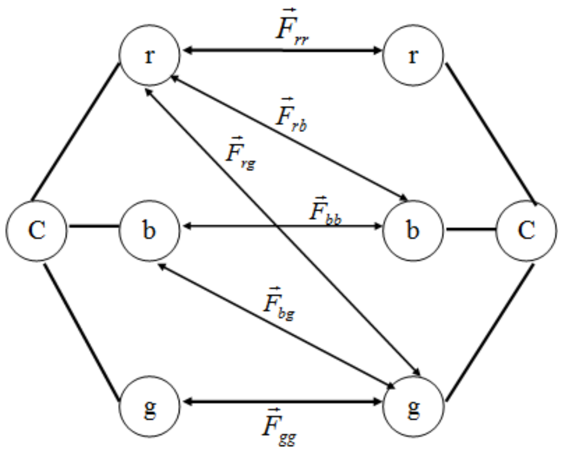

Fig. 2: Six types of strong interactions between color charges: red-red, green-green, blue-blue, red-green, red-blue, and green-blue interactions.

3.3 Strong force

The force $\vec{F}_{CC}$ is the strong interaction between color and color charges. Color charges have three varieties: red, blue, and green and thus six types of interactions: 1) the red-red interaction $\vec{F}_{rr}$, 2) the blue-blue interaction $\vec{F}_{bb}$, 3) the green-green interaction $\vec{F}_{gg}$, 4) the red-blue interaction $\vec{F}_{rb}$, 5) the red-green interaction $\vec{F}_{rg}$, and 6) the blue-green interaction $\vec{F}_{bg}$. Figure 2 shows these six types of color interactions.

Considering the strong interaction to be asymptotically free [19], we replace the color charge by

$$C \to r\,C\,; \tag{18}$$

this assumption represents that the color charge becomes less colorful if it is closer to each other, i.e., asymptotically colorless. Then the strong interaction between color charges can be rewritten by

$$\vec{F}_{CC} = C_1 C_2\,\hat{r}, \tag{19}$$

which is independent of the radial distance and consistent with measurement.

The strong interaction is the only one that can change the color of quarks in a hadron. A typical strong interaction is proton-neutron scattering, $p + n \longrightarrow n + p$. This is an interaction between the color charge of one up quark in proton and the color charge of one down quark in neutron via exchanging a π^+ , $u + d \longrightarrow d + u$ (see Figure 2). In other words, during this proton-neutron scattering an up quark in the proton changes into a down quark by emitting a π^+, meanwhile a down quark in the neutron changes into an up quark by absorbing the π^+. Another typical strong interaction is delta decay, $\Delta^0 \longrightarrow p + \pi^-$. This is an interaction between the color

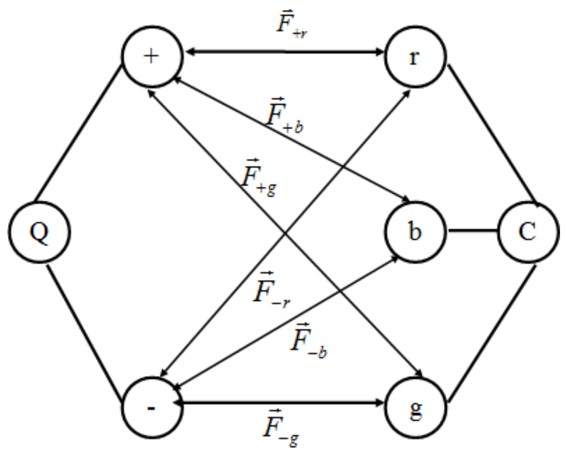

Fig. 3: Six types of weak interactions between electric and color charges: positive-red, positive-green, positive-blue, negative-red, negative-green, and negative-blue interactions.

charge of one down quark and the color charges of the other two quarks. In this interaction, a down quark emits a π^- and then becomes a up quark, $d \longrightarrow u + \pi^-$.

3.4 Weak force

The force $\vec{F}_{QC}$ is the weak interaction between electric and color charges. Considering electric charges with two varieties (positive and negative) and color charges with three varieties (red, blue, and green), we have also six types of weak interaction: 1) the positive-red interaction $\vec{F}_{+r}$, 2) the positive-blue interaction $\vec{F}_{+b}$, 3) the positive-green interaction $\vec{F}_{+g}$, 4) the negative-red interaction $\vec{F}_{-r}$, 5) the negative-blue interaction $\vec{F}_{-b}$, and 6) the negative-green interaction $\vec{F}_{-g}$. Figure 3 shows these six types of electric-color charge interactions.

Considering equation (18), we can represent the weak interaction by

$$\vec{F}_{QC} = \frac{QC}{r}\,\hat{\vec{r}}, \tag{20}$$

which is inversely proportional to the radial distance and consistent with measurement.

The weak interaction is the only one that can change the flavors of quarks in a hadron. A typical weak interaction is the neutron decay, $n \longrightarrow p + e^- + \bar{\nu}_e$. In this process, a down quark in the neutron changes into an up quark by emitting W^- boson, which lives about 10^{-26} seconds and then breaks into a high-energy electron and an electron antineutrino, i.e., $d \longrightarrow u + W^-$ and then $W^- \longrightarrow u + e^- + \bar{\nu}_e$. There are actually two interactions involved in this neutron decay. One is the interaction between electric and color charges inside the down quark, which is changed into an up quark by emitting a W^- boson. Another is the interaction inside W^-, which is broken into an electron and an electron antineutrino. Since W^- is composed of an up antiquark and a down quark ($\bar{u}d$), we suggest that the down quark changes into an up quark by emitting an electron and then the up antiquark and the up quark annihilate into an electron antineutrino. It should be noted that an upper antiquark and an up quark usually forms an η particle, which may live about a few tens of nanoseconds and decay into other particles such as photons and pions, which further decay to nuons and nuon neutrinos and antineutrinos. The formation of η and decay to photons and pions may explain the solar neutrino missing problem and neutrino oscillations, the detail of which leaves for a next study.

3.5 Imaginary force

The other terms with the imaginary number in Eq. (14) are imaginary forces between real and imaginary energies. These imaginary forces should play essential roles in combining or separating imaginary energies with or from real energies. The physics of imaginary forces needs further investigations.

4 Summary

As a summary, we have appropriately suggested mass, radiation, electric charge, and color charge as the four fundamental elements of nature. Mass and radiation are two types of real energy, while electric and color charges are considered as two forms of imaginary energy. we have described the nature as a system of complex energy and classically unified all the fundamental interactions of nature into a single interaction between complex energies. Through this classical unification theory, we provide a more general understanding of nature fundamental elements and interactions, especially the weak interaction as an interaction between electric and color charges without assuming a weak charge. The interaction between real energies is the gravitational force, which has three types: mass-mass, mass-radiation, and radiation-radiation interactions. Calculating the work done by the mass-radiation gravitation on a photon derives the Einsteinian gravitational redshift. Calculating the work done on a photon from an object by the radiation-radiation gravitation derives a radiation redshift, which is much smaller than the gravitational redshift. The interaction between imaginary energies is the electromagnetic (between electric charges), weak (between electric and color charges), and strong (between color charges) interactions. In addition, we have four imaginary forces between real and imaginary energies, which are mass-electric charge, radiation-electric charge, mass-color charge, and radiation-color charge interactions. Therefore, among the four fundamental elements, we have in total ten (six real and four imaginary) fundamental interactions. In addition, we introduce a three-dimensional energy space to describe all types of matter or particles including quarks and antiquarks.

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