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Relationships between the Electromagnetic and Strong Forces

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Abstract
The origin of the strong forces is suggested. The essential properties of the gluon and color charges are also discussed. The color charges (red, blue, and green) are the magnetic charges (the magnetic monopole at time axis and the spin magnetic moment at space axis). Gluon is a photon emitted and absorbed by color charges. The strong forces can be generated because the photons (electromagnetic waves) called gluons, which are emitted and absorbed by the color charges (the spin magnetic moment and the magnetic monopoles), are exchanged between quarks. One dimensional property of the strong force in the range of 10^{-15} m (i.e., confinement of quarks and gluons) can be explained by the fact that the magnetic field originating from the magnetic monopole (color charge) are confined within the one-dimension by the induced spin magnetic field originating from the moving electric charge (Ampère's law).

Keywords: Magnetic Monopole; Color Charge; Photonic Gauge Gluon; Confinement of the Quarks and Photonic Gauge Gluons.

1. Introduction

The effect of vibronic interactions and electron–phonon interactions [1–7] in molecules and crystals is an important topic of discussion in modern chemistry and physics. The vibronic and electron–phonon interactions play an essential role in various research fields such as the decision of molecular structures, Jahn–Teller effects, Peierls distortions, spectroscopy, electrical conductivity, and superconductivity. We have investigated the electron–phonon interactions in various charged molecular crystals for more than ten years [1–8]. In particular, in 2002, we predicted the occurrence of superconductivity as a consequence of vibronic interactions in the negatively charged picene, phenanthrene, and coronene [8]. Recently, it was reported that these trianionic molecular crystals exhibit superconductivity [9].

Related to the research of superconductivity as described above, in the recent research [10,11], we explained the mechanism of the Ampère's law (experimental rule discovered in 1820) and the Faraday's law (experimental rule discovered in 1831) in normal metallic and superconducting states [12], on the basis of the theory suggested in our previous researches [1–7]. Furthermore, we discussed how the left-handed helicity magnetic field can be induced when the negatively charged particles such as electrons move [13]. That is, we discussed the relationships between the electric and magnetic fields [13]. Furthermore, by comparing the electric charge with the spin magnetic moment and mass, we suggested the origin of the electric charge in a particle. Furthermore, we discussed the relationships between the magnetic forces, gravity, electric forces, and electromagnetic forces.

Furthermore, in the previous research, we discussed the origin of the gravity, by comparing the gravity with the electric and magnetic forces. Furthermore, we showed the reason why the gravity is much smaller than the electric and magnetic forces [14].

In this research, we will discuss the origin of the strong forces, by comparing the strong force with the gravitational, electric, magnetic, and electromagnetic forces. We will also discuss the essential properties of the gluon and color charges. Furthermore, we will also discuss the reason why the quarks and gluons are confined in hadron.

2. Theoretical Background

2.1 Relationships between the Spin Magnetic Moment and Mass at Space Axis

According to the special relativity and Minkowski's research, the medium for an electron is time as well as space. In this article, the charges of the gravity (massive charge (mass)), of the electric force (electric charge), of the magnetic forces (spin magnetic moment), of the electromagnetic force, and of the strong force (color charge) are denoted as q_{g}, q_{e}, q_{m}, q_{em}, and q_{c}, respectively (Figs. 1–3). Furthermore, the gauge bosons of the gravity (graviton), of the electric force (electric photon), of the magnetic forces (magnetic photon), of the electromagnetic force (electromagnetic photon), and of the strong force (gluon) are denoted as γ_{g}, γ_{e}, γ_{m}, γ_{em}, and γ_{c}, respectively.

Let us consider a particle such as an up quark in three-dimensional space axis (Figs. 1 and 3). We can consider that the spin electronic state for a quark with massive charge q_{g} and momentum $\boldsymbol{k}$ can be composed from the right-handed chirality $\left|\boldsymbol{R}\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ or left-handed chirality $\left|\boldsymbol{L}\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ elements, defined as,

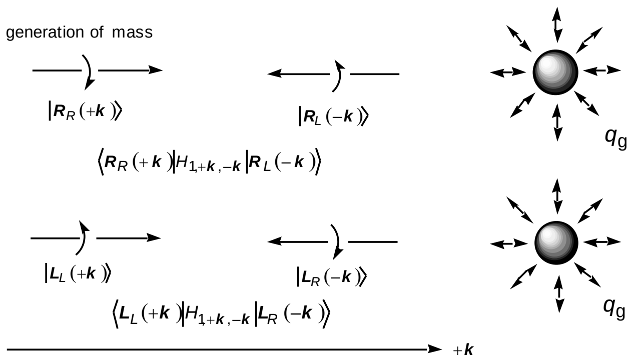

Fig. 1. Origin of massive charge.

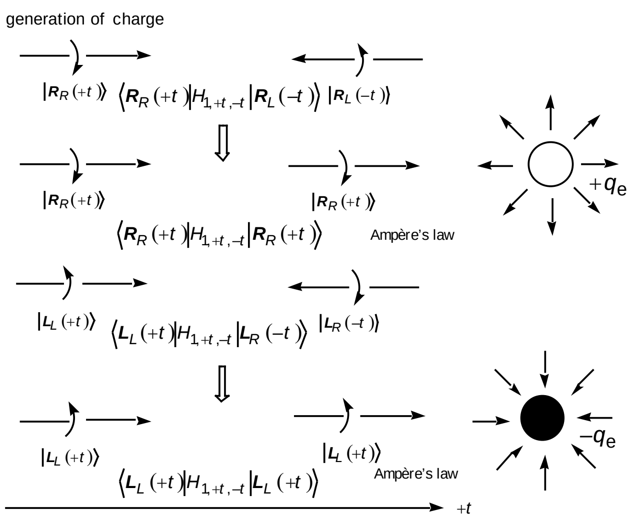

Fig. 2. Origin of electric charge.

$$\left|R\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle = c_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right)\left|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle + c_{\boldsymbol{R}_L}\left(q_{\mathrm{g}}\right)\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle, \tag{1}$$

$$\left|L\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle = c_{\boldsymbol{L}_L}\left(q_{\mathrm{g}}\right)\left|\boldsymbol{L}_L(+\boldsymbol{k})\right\rangle + c_{\boldsymbol{L}_R}\left(q_{\mathrm{g}}\right)\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle, \tag{2}$$

where the $\left|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and $\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ denote the right- and left-handed helicity elements in the right-handed chirality $\left|R\uparrow\left(q_{\mathrm{g}}\right)\right\rangle$ state, respectively, and the $\left|\boldsymbol{L}_L(+\boldsymbol{k})\right\rangle$ and $\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle$ denote the left- and right-handed helicity elements in the left-handed chirality $\left|L\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ state, respectively, at the space axis. By considering the normalizations of the $\left|R\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ and $\left|L\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ states, the relationships between the coefficients ($0 \le c_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right) c_{\boldsymbol{R}_L}\left(q_{\mathrm{g}}\right) c_{\boldsymbol{L}_L}\left(q_{\mathrm{g}}\right) c_{\boldsymbol{L}_R}\left(q_{\mathrm{g}}\right) \le 1$) can be expressed as

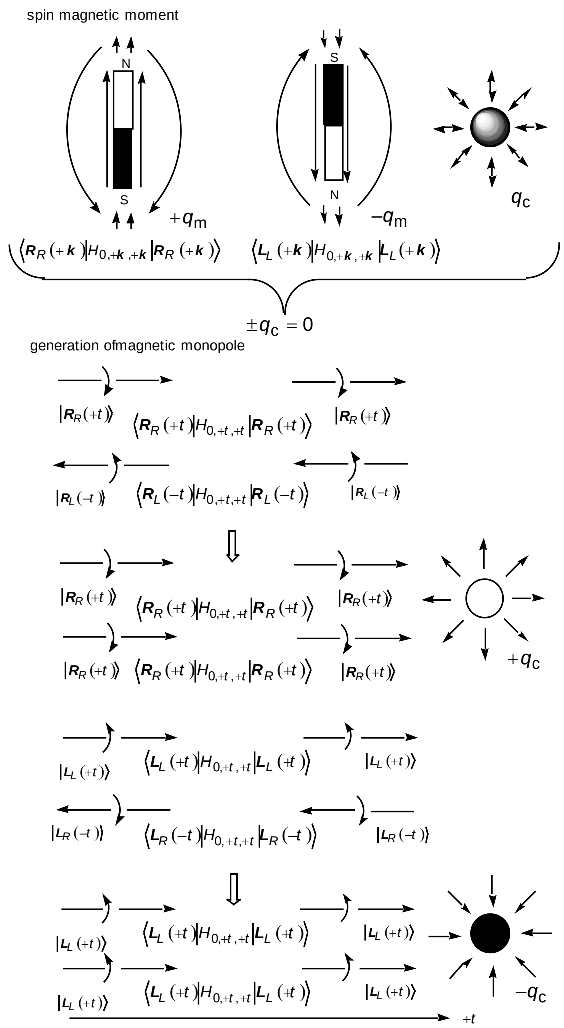

Fig. 3. Origin of spin magnetic moment and color charge (magnetic monopole).

$$\left\langle R\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\middle|R\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle = c^2_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right) + c^2_{\boldsymbol{R}_L}\left(q_{\mathrm{g}}\right) = 1, \tag{3}$$

$$\left\langle L\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\middle|L\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle = c^2_{\boldsymbol{L}_L}\left(q_{\mathrm{g}}\right) + c^2_{\boldsymbol{L}_R}\left(q_{\mathrm{g}}\right) = 1. \tag{4}$$

Let us next consider the Hamiltonian $H_{\boldsymbol{k}}$ for a quark at the space axis, as expressed as,

$$H_{\boldsymbol{k}} = H_{0,+\boldsymbol{k},+\boldsymbol{k}} + H_{1,+\boldsymbol{k},-\boldsymbol{k}}. \tag{5}$$

The energy for the right-handed chirality $\left|R\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ state can be estimated as

$$\left\langle R\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\middle|H_{\boldsymbol{k}}\middle|R\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$$
$$= \left(2c^2_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right)-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}} + 2c_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right)\sqrt{1-c^2_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right)}\,\varepsilon_{q_{\mathrm{g}\infty},\boldsymbol{R}}$$

$$= \varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}(q_{\mathrm{g}}) + \varepsilon_{q_{\mathrm{g}},\boldsymbol{R}}(q_{\mathrm{g}}) \qquad (6)$$

where $\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}}(q_{\mathrm{g}})$ denotes the spin magnetic energies for the right- $|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ handed helicity element in the right-handed chirality $|\boldsymbol{R}\uparrow(q_{\mathrm{g}},\boldsymbol{k})\rangle$, and can be defined as

$$\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}}(q_{\mathrm{g}}) = \langle \boldsymbol{R}_R(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_R(+\boldsymbol{k})\rangle, \qquad (7)$$

and the $\varepsilon_{q_{\mathrm{g}\infty},\boldsymbol{R}}$ denotes the mass energy originating from the interaction between the right- $|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and left- $|\boldsymbol{R}_L(-\boldsymbol{k})\rangle$ handed helicity elements, which depends on the kind of particle, and related to the Higgs vacuum expectation value and Yukawa coupling constant,

$$\varepsilon_{q_{\mathrm{g}\infty},\boldsymbol{R}} = \langle \boldsymbol{R}_R(+\boldsymbol{k})|H_{1,+\boldsymbol{k},-\boldsymbol{k}}|\boldsymbol{R}_L(-\boldsymbol{k})\rangle, \qquad (8)$$

and the $\varepsilon_{q_{\mathrm{g}},\boldsymbol{R}}(q_{\mathrm{g}})$ denotes the generated mass energy for the right-handed chirality $|\boldsymbol{R}\uparrow(q_{\mathrm{g}},\boldsymbol{k})\rangle$ state,

$$\varepsilon_{q_{\mathrm{g}},\boldsymbol{R}}(q_{\mathrm{g}}) = 2c_{\boldsymbol{R}_R}(q_{\mathrm{g}})\sqrt{1-c^2_{\boldsymbol{R}_R}(q_{\mathrm{g}})}\,\varepsilon_{q_{\mathrm{g}\infty},\boldsymbol{R}}, \qquad (9)$$

and furthermore, $\varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}(q_{\mathrm{g}})$ denotes the spin magnetic energy for the right-handed chirality state with mass q_{g},

$$\begin{aligned}
\varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}(q_{\mathrm{g}}) &= \left\{c^2_{\boldsymbol{R}_R}(q_{\mathrm{g}}) - c^2_{\boldsymbol{R}_L}(q_{\mathrm{g}})\right\}\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}} \\
&= \left(2c^2_{\boldsymbol{R}_R}(q_{\mathrm{g}})-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}} + c^2_{\boldsymbol{R}_L}(q_{\mathrm{g}})\left(\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}} + \varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}}\right) \\
&= \left(2c^2_{\boldsymbol{R}_R}(q_{\mathrm{g}})-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}} + c^2_{\boldsymbol{R}_L}(q_{\mathrm{g}})\,\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{RL}} \\
&= \left(2c^2_{\boldsymbol{R}_R}(q_{\mathrm{g}})-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}}, \qquad (10)
\end{aligned}$$

where the $\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{RL}}$ denotes the cancellation energy (0) as a consequence of the mixture of the angular momentum for the right- and left-handed helicity elements,

$$\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{RL}} = \varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}} + \varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}} = 0, \qquad (11)$$

$$\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}}(q_{\mathrm{g}}) = \langle \boldsymbol{R}_L(-\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_L(-\boldsymbol{k})\rangle. \qquad (12)$$

Similar discussions can be made in the energy for the left-handed chirality $|\boldsymbol{L}\downarrow(q_{\mathrm{g}},\boldsymbol{k})\rangle$ states,

$$\begin{aligned}
&\langle \boldsymbol{L}\downarrow(q_{\mathrm{g}})|H_{\boldsymbol{k}}|\boldsymbol{L}\downarrow(q_{\mathrm{g}})\rangle \\
&= \left(2c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}})-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}} + 2c_{\boldsymbol{L}_L}(q_{\mathrm{g}})\sqrt{1-c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}})}\,\varepsilon_{q_{\mathrm{g}\infty},\boldsymbol{L}} \\
&= \varepsilon_{q_{\mathrm{m}},\boldsymbol{L}}(q_{\mathrm{g}}) + \varepsilon_{q_{\mathrm{g}},\boldsymbol{L}}(q_{\mathrm{g}}) \qquad (13)
\end{aligned}$$

$$\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}}(q_{\mathrm{g}}) = \langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_L(+\boldsymbol{k})\rangle, \qquad (14)$$

$$\varepsilon_{q_{\mathrm{g}\infty},\boldsymbol{L}} = \langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{1,+\boldsymbol{k},-\boldsymbol{k}}|\boldsymbol{L}_R(-\boldsymbol{k})\rangle, \qquad (15)$$

$$\varepsilon_{q_{\mathrm{g}},\boldsymbol{L}}(q_{\mathrm{g}}) = 2c_{\boldsymbol{L}_L}(q_{\mathrm{g}})\sqrt{1-c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}})}\,\varepsilon_{q_{\mathrm{g}\infty},\boldsymbol{L}}, \qquad (16)$$

$$\begin{aligned}
\varepsilon_{q_{\mathrm{m}},\boldsymbol{L}}(q_{\mathrm{g}}) &= \left\{c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}}) - c^2_{\boldsymbol{L}_R}(q_{\mathrm{g}})\right\}\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}} \\
&= \left(2c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}})-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}} + c^2_{\boldsymbol{L}_R}(q_{\mathrm{g}})\left(\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}} + \varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}}\right) \\
&= \left(2c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}})-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}} + c^2_{\boldsymbol{L}_R}(q_{\mathrm{g}})\,\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{RL}} \\
&= \left(2c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}})-1\right)\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{L}}, \qquad (17)
\end{aligned}$$

$$\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{R}}(q_{\mathrm{g}}) = \langle \boldsymbol{L}_R(-\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_R(-\boldsymbol{k})\rangle. \qquad (18)$$

2.2 Relationships between the Magnetic Charge (Magnetic Monopole) and Electric Charge at Time Axis

Let us consider a quark in time axis, as shown in Figs. 2 and 3. We can consider that the spin state for a quark with electric charge q_{e} can be composed from the right-handed chirality $|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\rangle$ or left-handed chirality $|\boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\rangle$ elements, defined as,

$$|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\rangle = c_{\boldsymbol{R}_R}(q_{\mathrm{e}})|\boldsymbol{R}_R(+t)\rangle + c_{\boldsymbol{R}_L}(q_{\mathrm{e}})|\boldsymbol{R}_L(-t)\rangle, \qquad (19)$$

$$|\boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\rangle = c_{\boldsymbol{L}_L}(q_{\mathrm{e}})|\boldsymbol{L}_L(+t)\rangle + c_{\boldsymbol{L}_R}(q_{\mathrm{e}})|\boldsymbol{L}_R(-t)\rangle, \qquad (20)$$

where the $|\boldsymbol{R}_R(+t)\rangle$ and $|\boldsymbol{R}_L(-t)\rangle$ denote the right- and left-handed helicity elements in the right-handed chirality $|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\rangle$ state, respectively, and the $|\boldsymbol{L}_L(+t)\rangle$ and $|\boldsymbol{L}_R(-t)\rangle$ denote the left- and right-handed helicity elements in the left-handed chirality $|\boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\rangle$ state, respectively. By considering the normalization of the $|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\rangle$ and $|\boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\rangle$ states, the relationships between the coefficients ($0 \le c_{\boldsymbol{R}_R}(q_{\mathrm{e}}), c_{\boldsymbol{R}_L}(q_{\mathrm{e}}), c_{\boldsymbol{L}_L}(q_{\mathrm{e}}), c_{\boldsymbol{L}_R}(q_{\mathrm{e}}) \le 1$) can be expressed as

$$\left\langle \boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\middle|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\right\rangle = c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})+c^2_{\boldsymbol{R}_L}(q_{\mathrm{e}})=1, \quad (21)$$

$$\left\langle \boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\middle|\boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\right\rangle = c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})+c^2_{\boldsymbol{L}_R}(q_{\mathrm{e}})=1. \quad (22)$$

Let us next consider the Hamiltonian H_t for a quark at the time axis, as expressed as,

$$H_t = H_{0,+t,+t} + H_{1,+t,-t}. \quad (23)$$

The energy for the right-handed chirality $\left|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\right\rangle$ states can be estimated as

$$\begin{aligned}
&\left\langle \boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\middle|H_t\middle|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\right\rangle \\
&= c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} + c^2_{\boldsymbol{R}_L}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} \\
&+2c_{\boldsymbol{R}_R}(q_{\mathrm{e}})\sqrt{1-c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})}\,\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{R}} \\
&= \left(c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})+c^2_{\boldsymbol{R}_L}(q_{\mathrm{e}})\right)\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} \\
&+2c_{\boldsymbol{R}_R}(q_{\mathrm{e}})\sqrt{1-c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})}\,\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{R}} \\
&= \varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}}) + \varepsilon_{q_{\mathrm{e}},\boldsymbol{R}}(q_{\mathrm{e}}),
\end{aligned} \quad (24)$$

where $\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}}$ and $\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}}$ denote the energies for the right- $\left|\boldsymbol{R}_R(+t)\right\rangle$ and left- $\left|\boldsymbol{R}_L(+t)\right\rangle$ handed helicity elements in the right-handed chirality $\left|\boldsymbol{R}\uparrow(q_{\mathrm{e}},+t)\right\rangle$, and can be defined as

$$\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} = \left\langle \boldsymbol{R}_R(+t)\middle|H_{0,+t,+t}\middle|\boldsymbol{R}_R(+t)\right\rangle, \quad (25)$$

$$\begin{aligned}
\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} &= \left\langle \boldsymbol{R}_L(-t)\middle|H_{0,+t,+t}\middle|\boldsymbol{R}_L(-t)\right\rangle \\
&= \left\langle \boldsymbol{R}_R(+t)\middle|H_{0,+t,+t}\middle|\boldsymbol{R}_R(+t)\right\rangle \\
&= \varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}},
\end{aligned} \quad (26)$$

and the $\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{R}}$ denotes the electric charge energy originating from the interaction between the right- $\left|\boldsymbol{R}_R(+t)\right\rangle$ and left- $\left|\boldsymbol{R}_L(-t)\right\rangle$ handed helicity elements at the time axis, which depends on the kind of particle,

$$\begin{aligned}
\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{R}} &= \left\langle \boldsymbol{R}_R(+t)\middle|H_{1,+t,-t}\middle|\boldsymbol{R}_L(-t)\right\rangle \\
&= \left\langle \boldsymbol{R}_R(+t)\middle|H_{1,+t,-t}\middle|\boldsymbol{R}_R(+t)\right\rangle,
\end{aligned} \quad (27)$$

and furthermore, $\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}})$ denotes the magnetic monopole (color charge (q_{c})) energy for the right-handed chirality state with charge q_{e},

$$\begin{aligned}
\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}}) &= c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} + c^2_{\boldsymbol{R}_L}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} \\
&= \left(c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})+c^2_{\boldsymbol{R}_L}(q_{\mathrm{e}})\right)\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} \\
&= \varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}},
\end{aligned} \quad (28)$$

and the $\varepsilon_{q_{\mathrm{e}},\boldsymbol{R}}(q_{\mathrm{e}})$ denotes the electric energy for the right-handed chirality state with charge q_{e},

$$\varepsilon_{q_{\mathrm{e}},\boldsymbol{R}}(q_{\mathrm{e}}) = 2c_{\boldsymbol{R}_R}(q_{\mathrm{e}})\sqrt{1-c^2_{\boldsymbol{R}_R}(q_{\mathrm{e}})}\,\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{R}}. \quad (29)$$

Similar discussions can be made in the energy for the left-handed chirality $\left|\boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\right\rangle$ states,

$$\begin{aligned}
&\left\langle \boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\middle|H_t\middle|\boldsymbol{L}\downarrow(q_{\mathrm{e}},+t)\right\rangle \\
&= c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} + c^2_{\boldsymbol{L}_R}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} \\
&+2c_{\boldsymbol{L}_L}(q_{\mathrm{e}})\sqrt{1-c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})}\,\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{L}} \\
&= \left(c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})+c^2_{\boldsymbol{L}_R}(q_{\mathrm{e}})\right)\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} \\
&+2c_{\boldsymbol{L}_L}(q_{\mathrm{e}})\sqrt{1-c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})}\,\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{L}} \\
&= \varepsilon_{q_{\mathrm{c}},\boldsymbol{L}}(q_{\mathrm{e}}) + \varepsilon_{q_{\mathrm{e}},\boldsymbol{L}}(q_{\mathrm{e}}),
\end{aligned} \quad (30)$$

$$\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} = \left\langle \boldsymbol{L}_L(+t)\middle|H_{0,+t,+t}\middle|\boldsymbol{L}_L(+t)\right\rangle, \quad (31)$$

$$\begin{aligned}
\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} &= \left\langle \boldsymbol{L}_R(-t)\middle|H_{0,+t,+t}\middle|\boldsymbol{L}_R(-t)\right\rangle \\
&= \left\langle \boldsymbol{L}_L(+t)\middle|H_{0,+t,+t}\middle|\boldsymbol{L}_L(+t)\right\rangle \\
&= \varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}},
\end{aligned} \quad (32)$$

$$\begin{aligned}
\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{L}} &= \left\langle \boldsymbol{L}_L(+t)\middle|H_{1,+t,-t}\middle|\boldsymbol{L}_R(-t)\right\rangle \\
&= \left\langle \boldsymbol{L}_L(+t)\middle|H_{1,+t,-t}\middle|\boldsymbol{L}_L(+t)\right\rangle,
\end{aligned} \quad (33)$$

$$\begin{aligned}
\varepsilon_{q_{\mathrm{c}},\boldsymbol{L}}(q_{\mathrm{e}}) &= c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} + c^2_{\boldsymbol{L}_R}(q_{\mathrm{e}})\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{R}} \\
&= \left(c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})+c^2_{\boldsymbol{L}_R}(q_{\mathrm{e}})\right)\varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}} \\
&= \varepsilon_{q_{\mathrm{c}\infty},\boldsymbol{L}},
\end{aligned} \quad (34)$$

$$\varepsilon_{q_{\mathrm{e}},\boldsymbol{L}}(q_{\mathrm{e}}) = 2c_{\boldsymbol{L}_L}(q_{\mathrm{e}})\sqrt{1-c^2_{\boldsymbol{L}_L}(q_{\mathrm{e}})}\,\varepsilon_{q_{\mathrm{e}\infty},\boldsymbol{L}}. \quad (35)$$

3. Relationships between the Spin Magnetic Moment, Massive Charge, Electric Charge, and Color Charge

3.1 Spin Magnetic Moment

The energies for the spin magnetic moment for the $\left|\boldsymbol{R}\uparrow(q_{\mathrm{g}},\boldsymbol{k})\right\rangle$ state can be expressed as Eqs. (7) and (10). At the time of the Big Bang, the $\varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}(q_{\mathrm{g}})$ and

$\varepsilon_{q_{\mathrm{m}},\boldsymbol{L}}(q_{\mathrm{g}})$ values were the maximum, as shown in Fig. 4. That is, there was no mixture between right- $|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and left- $|\boldsymbol{R}_L(-\boldsymbol{k})\rangle$ handed helicity elements, and thus the spin magnetic moment was the largest at the Big Bang. In other words, the mass and intrinsic electric charge were not generated at that time. However, since temperatures immediately decrease after Big Bang, because of any origin (i.e., Higgs boson, broken symmetry of chirality etc.), the mixture between the right- $|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and left- $|\boldsymbol{R}_L(-\boldsymbol{k})\rangle$ handed helicity elements has begun to occur. The mixture between the right- $|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and left- $|\boldsymbol{R}_L(-\boldsymbol{k})\rangle$ handed helicity elements increases with an increase in time (with a decrease in the $c_{\boldsymbol{R}_R}(q_{\mathrm{g}})$ value). Similar discussions can be made in the $|\boldsymbol{L}\downarrow(q_{\mathrm{g}},\boldsymbol{k})\rangle$ state.

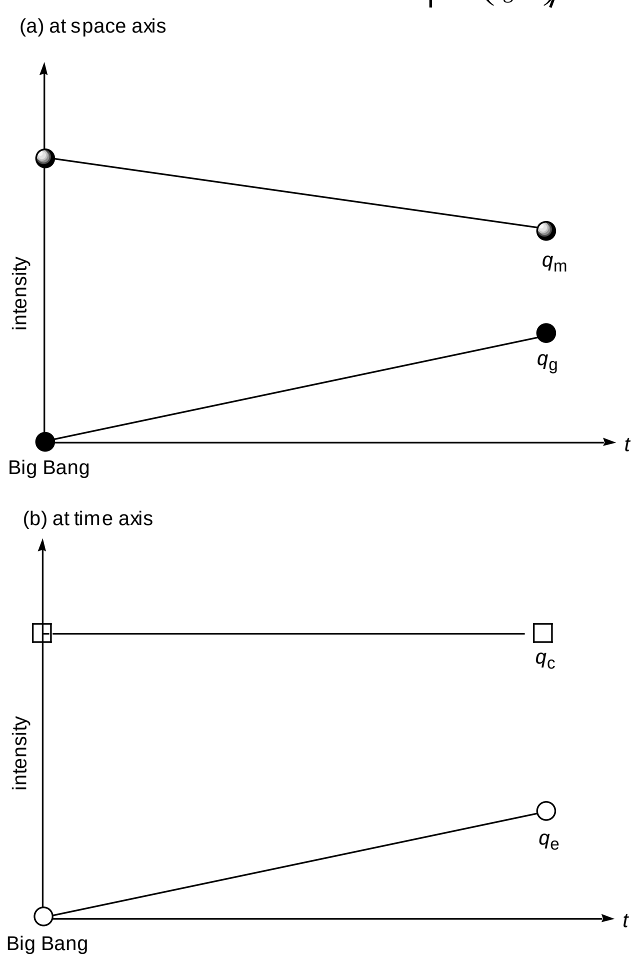

Fig. 4. (a) Intensity of the spin magnetic moment (shaded circles) and mass (closed circles) versus time. (b) Intensity of the magnetic monople (square) and electric charge (opened circles) versus time.

We can see from Fig. 3 that the $\varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}(q_{\mathrm{g}})$ and $\varepsilon_{q_{\mathrm{m}},\boldsymbol{L}}(q_{\mathrm{g}})$ values are not equivalent in the space axis. The total chirality and momentum in the $\langle \boldsymbol{R}_R(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and $\langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_L(+\boldsymbol{k})\rangle$ terms in the both $|\boldsymbol{R}\uparrow(q_{\mathrm{g}},\boldsymbol{k})\rangle$ and $|\boldsymbol{L}\downarrow(q_{\mathrm{g}},\boldsymbol{k})\rangle$ states are not zero. This is the reason why the number of elements for magnetic spin moments is two, and thus there are attractive and repulsive forces between two magnetic moments.

The spin magnetic energy is proportional to the $\langle \boldsymbol{R}_R(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and $\langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_L(+\boldsymbol{k})\rangle$ values (Fig. 3),

$$\varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}(q_{\mathrm{g}}) = k_{q_{\mathrm{m}},\boldsymbol{R}}\langle \boldsymbol{R}_R(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_R(+\boldsymbol{k})\rangle, \quad (36)$$

$$\varepsilon_{q_{\mathrm{m}},\boldsymbol{L}}(q_{\mathrm{g}}) = k_{q_{\mathrm{m}},\boldsymbol{L}}\langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_L(+\boldsymbol{k})\rangle. \quad (37)$$

The $k_{q_{\mathrm{m}},\boldsymbol{R}}$ and $k_{q_{\mathrm{m}},\boldsymbol{L}}$ values are different between the kinds of particles. This is the reason why we cannot theoretically predict the intensity of the spin magnetic moment for each particle. In summary, because of the $\langle \boldsymbol{R}_R(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and $\langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_L(+\boldsymbol{k})\rangle$ terms, originating from the finite right- and left-handed helicity elements, respectively, the magnetic field goes from the infinitesimal source point to the infinitesimal inlet point at finite space axis. This is the reason why the path of the magnetic field is like loop-type, as shown in Fig. 3.

Furthermore, we can also consider the residual spin magnetic energy ($\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{RL}}$) originating from the fluctuation of the mixture of the angular momentum for the right- and left-handed helicity elements (Fig. 3),

$$\begin{aligned}\varepsilon_{q_{\mathrm{m}\infty},\boldsymbol{RL}} &= k_{q_{\mathrm{m}},\boldsymbol{RL}}\Big\{\langle \boldsymbol{R}_R(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_R(+\boldsymbol{k})\rangle \\ &\quad + \langle \boldsymbol{R}_L(-\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_L(-\boldsymbol{k})\rangle\Big\} \\ &= k_{q_{\mathrm{m}},\boldsymbol{RL}}\Big\{\langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_L(+\boldsymbol{k})\rangle \\ &\quad + \langle \boldsymbol{L}_R(-\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_R(-\boldsymbol{k})\rangle\Big\} \quad (38)\end{aligned}$$

The $k_{q_{\mathrm{m}},\boldsymbol{RL}}$ values are different between the kinds of particles.

3.2 Mass

The mass energy $\varepsilon_{q_g,\boldsymbol{R}}(q_g)$ for the right-handed chirality $\left|\boldsymbol{R}\uparrow(q_g,\boldsymbol{k})\right\rangle$ element can be defined as Eqs. (8) and (9). At the time of the Big Bang, the $\varepsilon_{q_g,\boldsymbol{R}}(q_g)$ value was the minimum ($c_{\boldsymbol{R}_R}(q_g)=1$), as shown in Fig. 4. That is, there was no mixture between the right- $\left|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and left- $\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ handed helicity elements, and thus the mass energy was zero at the Big Bang. In other words, the mass was not generated at that time. However, after that, temperature significantly decreases, and thus because of any origin (i.e., Higgs boson, broken symmetry of chirality etc.), the mixture between the right- $\left|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and left- $\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ handed helicity elements has begun to occur. The mixture between the right- $\left|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and left- $\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ handed helicity elements increases with an increase in time (with a decrease in the $c_{\boldsymbol{R}_R}(q_g)$ value). Similar discussions can be made in the $\left|\boldsymbol{L}\downarrow(q_g,\boldsymbol{k})\right\rangle$ state.

The mass energy is proportional to the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle$ values (Fig. 1),

$$\begin{aligned}\varepsilon_{q_g,\boldsymbol{R}}(q_g)&=\varepsilon_{q_g,\boldsymbol{L}}(q_g)\\&=k_{q_g}\left\langle \boldsymbol{R}_R(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle\\&=k_{q_g}\left\langle \boldsymbol{L}_L(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle. \qquad (39)\end{aligned}$$

The k_{q_g} values are different between the kinds of particles. This is the reason why we do not theoretically predict the mass for each particle.

We can see from Fig. 1 that the $\varepsilon_{q_g,\boldsymbol{R}}(q_g)$ and $\varepsilon_{q_g,\boldsymbol{L}}(q_g)$ values are equivalent in the space axis. The total chirality and momentum in the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle$ terms in the both $\left|\boldsymbol{R}\uparrow(q_g,\boldsymbol{k})\right\rangle$ and $\left|\boldsymbol{L}\downarrow(q_g,\boldsymbol{k})\right\rangle$ states are zero. We can consider that the mass is generated by the mixture of the right- $\left|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and left- $\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ handed helicity elements at the space axis. In the real world we live, the reversible process ($-\boldsymbol{k}$) can be possible in the space axis while the reversible process ($-t$) cannot be possible in the time axis (irreversible). This is the reason why the number of elements for mass is only one, and thus there is only attractive force between two masses.

In summary, because of the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle$ terms, originating from the cancellation of the right- and left-handed helicity elements at space axis, the gravitational fields only spring out from the infinitesimal source point to any direction in space axis.

On the other hand, the total chirality and momentum in the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle$ states are zero not because of the intrinsic zero value but because of the cancellation of the large right- and left-handed helicity elements, which are the origin of the spin magnetic moment and the electric charge. Therefore, there is a possibility that the external potential energy ($\varepsilon_{q_g,\mathrm{external},\boldsymbol{R}}(q_g)$ and $\varepsilon_{q_g,\mathrm{external},\boldsymbol{L}}(q_g)$) for the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{R}_L(-\boldsymbol{k})\right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k})\right|H_{1,+\boldsymbol{k},-\boldsymbol{k}}\left|\boldsymbol{L}_R(-\boldsymbol{k})\right\rangle$ states can be very small but finite values (fluctuated and induced polarization effects). Therefore, the distortion of the spacetime axes can occur. That is, we can consider that the gravity can be considered to be the residual electromagnetic forces [14].

The most of extremely large energy generated at the time of the Big Bang has been stored in the particle as a large potential rest energy, and only small part of it is now used as very small gravitational energy. This is the reason why the gravity is much smaller than other three forces.

3.3 Electric Charge

The energy $\varepsilon_{q_e,\boldsymbol{R}}(q_e)$ for the right-handed chirality $\left|\boldsymbol{R}\uparrow(q_e,+t)\right\rangle$ element can be defined as Eqs. (27) and (29). At the time of the Big Bang, the $\varepsilon_{q_e,\boldsymbol{R}}(q_e)$ value was the minimum ($c_{\boldsymbol{R}_R}(q_e)=1$), as shown in Fig. 4. That is, there was no mixture between the right- $\left|\boldsymbol{R}_R(+t)\right\rangle$ and left- $\left|\boldsymbol{R}_L(-t)\right\rangle$ handed helicity elements, and thus the electric field energy was zero at the Big Bang. In other words, the electric charge was not generated at that time. However, after that, temperature significantly decreases, and thus because of any origin (i.e., Higgs boson, broken symmetry of chirality etc.), the mixture between the right- $\left|\boldsymbol{R}_R(+t)\right\rangle$ and left- $\left|\boldsymbol{R}_L(-t)\right\rangle$ helicity elements at the time axis has begun to occur. The mixture between the right- $\left|\boldsymbol{R}_R(+t)\right\rangle$ and left- $\left|\boldsymbol{R}_L(-t)\right\rangle$ handed helicity elements at the time axis increases with an increase in time (with a decrease in the $c_{\boldsymbol{R}_R}(q_e)$ value). Similar discussions can be made in the $|\boldsymbol{L}\downarrow(q_e,+t)\rangle\!\rangle$ state.

The electric field energy is proportional to the $\langle\boldsymbol{R}_R(+t)|H_{1,+t,-t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_L(+t)\rangle$ values (Fig. 2).

$$\varepsilon_{q_e,\boldsymbol{R}}(q_e)=k_{q_e,\boldsymbol{R}}\langle\boldsymbol{R}_R(+t)|H_{1,+t,-t}|\boldsymbol{R}_R(+t)\rangle, \qquad (40)$$

$$\varepsilon_{q_e,\boldsymbol{L}}(q_e)=k_{q_e,\boldsymbol{L}}\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_L(+t)\rangle. \qquad (41)$$

On the other hand, the $k_{q_e,\boldsymbol{R}}$ and $k_{q_e,\boldsymbol{L}}$ values are different between the kinds of particles.

We can see from Fig. 2 that the $\varepsilon_{q_e,\boldsymbol{R}}(q_e)$ and $\varepsilon_{q_e,\boldsymbol{L}}(q_e)$ values are equivalent in the space axis. The total momentum in $\langle\boldsymbol{R}_R(+t)|H_{1,+t,-t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_L(+t)\rangle$ terms in the both $|\boldsymbol{R}\uparrow(q_e,+t)\rangle\!\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle\!\rangle$ states are not zero. And the total chirality in the $\langle\boldsymbol{R}_R(+t)|H_{1,+t,-t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_L(+t)\rangle$ terms in the $|\boldsymbol{R}\uparrow(q_e,+t)\rangle\!\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle\!\rangle$ states are opposite by each other at time axis, as shown in Fig. 2. We can consider that the electric charge is generated by the mixture of the right- $|\boldsymbol{R}_R(+t)\rangle$ and left-handed $|\boldsymbol{R}_L(-t)\rangle$ handed helicity elements at the time axis. In the real world we live, the reversible process ($-\boldsymbol{k}$) can be possible in the space axis. This is the reason why the total chirality and momentum in the $\langle\boldsymbol{R}_R(+\boldsymbol{k})|H_{1,+\boldsymbol{k},-\boldsymbol{k}}|\boldsymbol{R}_L(-\boldsymbol{k})\rangle$ and $\langle\boldsymbol{L}_L(+\boldsymbol{k})|H_{1,+\boldsymbol{k},-\boldsymbol{k}}|\boldsymbol{L}_R(-\boldsymbol{k})\rangle$ values in the both $|\boldsymbol{R}\uparrow(q_g,\boldsymbol{k})\rangle\!\rangle$ and $|\boldsymbol{L}\downarrow(q_g,\boldsymbol{k})\rangle\!\rangle$ states are zero at the space axis, and the number of elements for mass is only one, and thus there is only attractive force between two masses. On the other hand, in the real world we live, the reversible process ($-t$) cannot be possible in the time axis (irreversible). Therefore, we must consider the $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_L(+t)\rangle$ state instead of the $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_R(-t)\rangle$ state. This is the reason why the total chirality in the $\langle\boldsymbol{R}_R(+t)|H_{1,+t,-t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_L(+t)\rangle$ values in the both $|\boldsymbol{R}\uparrow(q_e,+t)\rangle\!\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle\!\rangle$ states are not zero, and opposite by each other, and the number of elements for electric charge is two, and thus there are attractive and repulsive forces between two electric charges. Because of the $\langle\boldsymbol{R}_R(+t)|H_{1,+t,-t}|\boldsymbol{R}_R(+t)\rangle$ terms, the electric field only springs out from the infinitesimal source point to any direction in space and time axes. On the other hand, because of the $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_L(+t)\rangle$ terms, the electric field only comes into the infinitesimal inlet point from any direction in space and time axes. In summary, because of the $\langle\boldsymbol{R}_R(+t)|H_{1,+t,-t}|\boldsymbol{R}_L(-t)\rangle$ and $\langle\boldsymbol{L}_L(+t)|H_{1,+t,-t}|\boldsymbol{L}_R(-t)\rangle$ terms, originating from the cancellation of the right- and left-handed helicity elements, the electric field springs out from the infinitesimal source point to any direction in time axis, or comes into the infinitesimal inlet point from any direction in time axis.

3.4 Color Charge

The $\varepsilon_{q_c,\boldsymbol{R}}(q_e)$ for the right-handed chirality $|\boldsymbol{R}\uparrow(q_e,+t)\rangle\!\rangle$ element can be defined as Eqs. (25) and (28). At the time of the Big Bang, the $\varepsilon_{q_c,\boldsymbol{R}}(q_e)$ value was very large ($c_{\boldsymbol{R}_R}(q_e)=1$), as shown in Fig. 4. That is, there was no mixture between the right- $|\boldsymbol{R}_R(+t)\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle$ handed helicity elements, and thus the color charge (magnetic monopole) field was very large at the Big Bang. However, after that, temperature significantly decreases, and thus because of any origin (i.e., Higgs boson, broken symmetry of chirality etc.), the mixture between the right- $|\boldsymbol{R}_R(+t)\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle$ handed helicity elements at the time axis has begun to occur. The mixture between the right- $|\boldsymbol{R}_R(+t)\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle$ handed helicity elements at the time axis increases with an increase in time (with decrease in the $c_{\boldsymbol{R}_R}(q_e)$ value). On the other hand, it should be noted that the $\varepsilon_{q_c,\boldsymbol{R}}(q_e)$ value does not change with an increase in time (with decrease in the $c_{\boldsymbol{R}_R}(q_e)$ value) Similar discussions can be made in the $|\boldsymbol{L}\downarrow(q_e,+t)\rangle\!\rangle$ state.

The color field (spin magnetic field, residual magnetic field, and magnetic monopole field) energy can be expressed as (Figs. 3 and 5).

$$\begin{aligned}&\varepsilon_{q_c,\boldsymbol{RL}}(q_e)\\&=k_{q_c,\boldsymbol{RL}}\left\{c^2_{\boldsymbol{R}_R}(q_g)\langle\boldsymbol{R}_R(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_R(+\boldsymbol{k})\rangle\right.\\&\qquad\left.-c^2_{\boldsymbol{R}_L}(q_g)\langle\boldsymbol{R}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{R}_L(+\boldsymbol{k})\rangle\right\}\\&+k_{q_c,\boldsymbol{RL}}\left\{c^2_{\boldsymbol{L}_L}(q_g)\langle\boldsymbol{L}_L(+\boldsymbol{k})|H_{0,+\boldsymbol{k},+\boldsymbol{k}}|\boldsymbol{L}_L(+\boldsymbol{k})\rangle\right.\end{aligned}$$

$$-c_{L_R}^2 \left(q_g\right)\left\{\left\langle L_R(+k)\right| H_{0,+k,+k}\left| L_R(+k)\right\rangle\right\} \quad (42)$$

$$\varepsilon_{q_c,R}(q_e) = k_{q_c,R}\left\langle R_R(+t)\right| H_{0,+t,+t}\left| R_R(+t)\right\rangle, \quad (43)$$

$$\varepsilon_{q_c,L}(q_e) = k_{q_c,L}\left\langle L_L(+t)\right| H_{0,+t,+t}\left| L_L(+t)\right\rangle. \quad (44)$$

On the other hand, the $k_{q_c,R}$, $k_{q_c,L}$, and $k_{q_c,RL}$ values are different between the kinds of particles. We can consider that the three kinds of the color charges (red, blue, and green) states are composed from the three magnetic $\psi_{q_c,RL}(q_e)$, $\psi_{q_c,R}(q_e)$, and $\psi_{q_c,L}(q_e)$ states, having the energies of the $\varepsilon_{q_c,RL}(q_e)$, $\varepsilon_{q_c,R}(q_e)$, and $\varepsilon_{q_c,L}(q_e)$, respectively (Fig. 5). For example, we can consider that the energy for the color field originating from the red, blue, and green charges can be expressed as the $\varepsilon_{q_c,R}(q_e)$, $\varepsilon_{q_c,L}(q_e)$, and $\varepsilon_{q_c,RL}(q_e)$ values, respectively. Three color charges (red, blue, and green) can be explained if we define the magnetic monopole and magnetic moment expressed in Eqs. (42)–(44) as color charges (Figs. 3 and 5). Therefore, we can consider that the color charges in the strong force can originate from the magnetic monopole and the spin magnetic moment (Fig. 5).

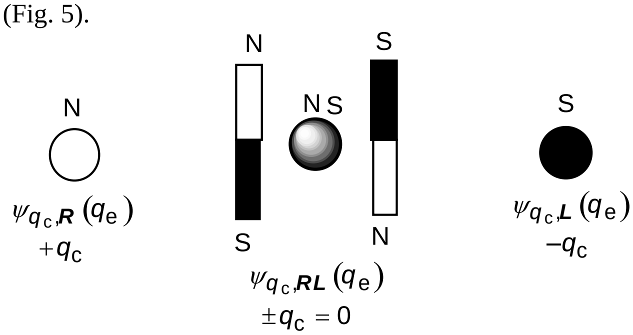

Fig. 5. Elements of the color charges.

The space integration of the magnetic field becomes zero because of its loop-type flowing, on the other hand, that of the electric field does not become zero because of its spring out-type flowing, as shown in Fig. 6,

$$\oint BdS = 0, \quad (45)$$

$$\oint EdS \neq 0. \quad (46)$$

Under the no external applied magnetic and electric field, there is no net magnetic field and induced current in any direction, on the other hand, there are net electric field in any direction equivalently, as shown in Fig. 6. This is the reason why the electric charge exists while no spin magnetic moment has been observed under the no external applied magnetic and electric field. Therefore, we can consider that the total magnetic moment for the spin $\psi_{q_c,RL}(q_e)$ state is 0, and those for the $\psi_{q_c,R}(q_e)$, and

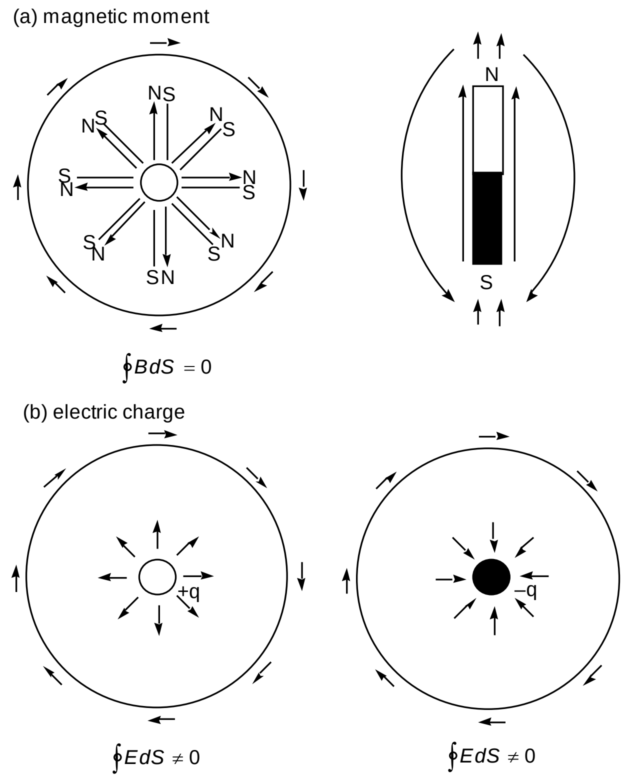

Fig. 6. Space integration under the no applied magnetic and electric field. (a) Spin magnetic momentum. (b) Electric charges.

$\psi_{q_c,L}(q_e)$ states are N and S magnetic monopoles, respectively.

We can see from Fig. 3 that the $\varepsilon_{q_c,R}(q_e)$ and $\varepsilon_{q_c,L}(q_e)$ values are equivalent in the space axis. The total momentum in the $\left\langle R_R(+t)\right| H_{0,+t,+t}\left| R_R(+t)\right\rangle$ and $\left\langle L_L(+t)\right| H_{0,+t,+t}\left| L_L(+t)\right\rangle$ terms in the both $\left| R\uparrow(q_e,+t)\right\rangle$ and $\left| L\downarrow(q_e,+t)\right\rangle$ states are not zero. And the total chirality in the $\left\langle R_R(+t)\right| H_{0,+t,+t}\left| R_R(+t)\right\rangle$ and $\left\langle L_L(+t)\right| H_{0,+t,+t}\left| L_L(+t)\right\rangle$ terms in the $\left| R\uparrow(q_e,+t)\right\rangle$ and $\left| L\downarrow(q_e,+t)\right\rangle$ states are opposite by each other at the time axis, as shown in Fig. 2. We can consider that the color charge is closely related to the magnetic monopole. We can consider that magnetic monopole is the right- $\left| R_R(+t)\right\rangle$ and left-handed $\left| R_L(-t)\right\rangle$ handed helicity elements of the angular momentum in quark at the time axis. In the real world we live, the reversible process ($-\boldsymbol{k}$) can be possible in the space axis. This is the reason why the total chirality and momentum in the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k}) \middle| H_{1,+\boldsymbol{k},-\boldsymbol{k}} \middle| \boldsymbol{R}_L(-\boldsymbol{k}) \right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k}) \middle| H_{1,+\boldsymbol{k},-\boldsymbol{k}} \middle| \boldsymbol{L}_R(-\boldsymbol{k}) \right\rangle$ terms in the both $\left| \boldsymbol{R}\uparrow(q_{\mathrm{g}},\boldsymbol{k}) \right\rangle$ and $\left| \boldsymbol{L}\downarrow(q_{\mathrm{g}},\boldsymbol{k}) \right\rangle$ states are zero at the space axis, and the number of elements for mass is only one, and thus there is only attractive force between two masses. On the other hand, in the real world we live, the reversible process ($-t$) cannot be possible in the time axis (irreversible). Therefore, we must consider the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ state instead of the $\left\langle \boldsymbol{R}_L(-t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_L(-t) \right\rangle$ state. This is the reason why the total chirality in the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ and $\left\langle \boldsymbol{L}_L(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{L}_L(+t) \right\rangle$ values in the both $\left| \boldsymbol{R}\uparrow(q_{\mathrm{e}},+t) \right\rangle$ and $\left| \boldsymbol{L}\downarrow(q_{\mathrm{e}},+t) \right\rangle$ states are not zero, and opposite by each other, and the number of elements for color charge at time axis is two. On the other hand, the number of elements for color charge at space axis is one. Furthermore, there is only attractive forces between two or three color charges. Because of the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ terms, the color field (magnetic monopole field) only springs out from the infinitesimal source point to any direction in space and time axes. On the other hand, because of the $\left\langle \boldsymbol{L}_L(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{L}_L(+t) \right\rangle$ terms, the color field (magnetic monopole field) only comes into the infinitesimal inlet point from any direction in space and time axes. In summary, because of the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ and $\left\langle \boldsymbol{L}_L(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{L}_L(+t) \right\rangle$ terms, originating from the right- $\left| \boldsymbol{R}_R(+t) \right\rangle$ and left-handed $\left| \boldsymbol{R}_L(-t) \right\rangle$ handed helicity elements of the angular momentum in quark at the time axis, the color field (magnetic monopole field) springs out from the infinitesimal source point to any direction in time axis, or comes into the infinitesimal inlet point from any direction in the time axis.

4. Relationships between the Electromagnetic and Strong Forces

4.1 Origin of the Strong Force

According to the quantum chromodynamics (QCD), it has been considered that the strong force is observed as a consequence of the exchange of gluon between two quarks. However, the essential properties of the color charge and gluon have not been elucidated in detail. That is, the reason why the strong force is observed as a consequence of the exchange of gluon between two quarks has not been elucidated. We discuss the mechanism how the quarks emit and absorb gluon and how the strong force is generated as a consequence of this process. We also discuss how the gluon in the strong force is related to the photon in electromagnetic force. We will use the terms "color charge" and "gluon" just as charge and the gauge boson for the medium of the strong force, respectively. That is, the properties of the color charge and the gluon in our theory are not necessarily the same as those in QCD.

Let us next look into the origin of the strong force (Fig. 7). According to our theory, quarks can have the magnetic monopoles, and leptons do not have the magnetic monopoles. This is the reason why we usually observe that quarks have the color charges while the leptons do not have color charges. Therefore, the $k_{q_{\mathrm{c}},\boldsymbol{R}}$, $k_{q_{\mathrm{c}},\boldsymbol{L}}$, and $k_{q_{\mathrm{c}},\boldsymbol{RL}}$ values are not zero for quarks, while the $k_{q_{\mathrm{c}},\boldsymbol{R}}$ and $k_{q_{\mathrm{c}},\boldsymbol{L}}$ values are zero for leptons. The color charges can be closely related to the spin magnetic moments and magnetic monopoles. That is, we can expect that the spin magnetic moments and the magnetic monopoles in quarks emit and absorb the photon (electromagnetic waves) called gluon. Therefore, the gluon can be considered to be a kind of photon emitted and absorbed by quarks. That is, we can consider that the strong forces can be generated because the photons (electromagnetic waves) called gluons emitted and absorbed by the spin magnetic moment and the magnetic monopoles called color charges in quarks are exchanged between quarks.

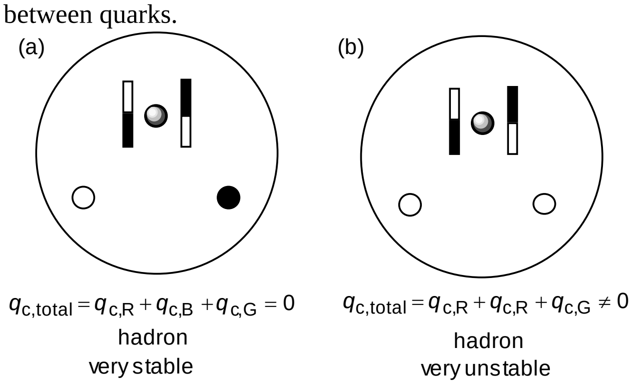

Fig. 7. Total color charges of a hadron. (a) zero total color charge. (b) nonzero total color charge.

The strong force between two or three quarks and anti-quarks is always attractive. This can be understood as follows. The total color charge (total external magnetic charge) must be 0 (white) ($q_{\mathrm{c,total}} = q_{\mathrm{c,R}} + q_{\mathrm{c,B}} + q_{\mathrm{c,G}} = 0$) when the particle is very stable (Fig. 7 (a)). When the total color charges in two or three quarks are 0 (white), the total magnetic charge within a hadron becomes 0 (Fig. 7 (a)). In such a case, the attractive interactions between the N and S magnetic monopoles can become strong and thus the magnetic states can be very stable. On the other hand, if the total color charges in two or three quarks are not zero (red, blue, or green), the repulsive interactions between the N and N (or S and S) magnetic monopoles can become strong and thus the magnetic states can be very unstable (Fig. 7 (b)).

This is very similar to the electric charge in electromagnetic forces. In general, the neutral materials are very stable because of the significant attractive electric forces between two electric charges. In a similar way, the total color charge (total external magnetic charge) must be white (colorless) ($q_{\mathrm{c,total}} = q_{\mathrm{c,R}} + q_{\mathrm{c,B}} + q_{\mathrm{c,G}} = 0$) when the particle is very stable (Fig. 7 (a)).

4.2 Asymptotic Freedom and Confinement of Quarks and Gluons

According to the experimental results, the strong forces $F(r)$ as a function of the distance r between two quarks can be expressed as,

$$F(r) = \frac{4}{3}\frac{\alpha_s}{r^2}\Theta(r_0 - r) + F(r_0)\Theta(r - r_0), \qquad (47)$$

where

$$r_0 \approx 10^{-16} \sim 10^{-18}\ [\mathrm{m}], \qquad (48)$$

$$\Theta(x) = 1 \text{ for } x > 0$$
$$= 0 \text{ for } x < 0. \qquad (49)$$

We can see from Eqs. (47)–(49) that the $F(r)$ values become constant if the r value is larger than $10^{-16} \sim 10^{-18}$ [m], and those are inversely proportional to the r^2 values if the r value is smaller than $10^{-16} \sim 10^{-18}$ [m].

When the distance (r) between the two quarks is relatively large (longer than about $10^{-16} \sim 10^{-18}$ [m]) (region C) (Fig. 8), the strong force between two quarks does not change with an increase in the r value. This can be understood as follows. At $r > 10^{-16} \sim 10^{-18}$ [m] (Fig. 8), that is, at relatively low energy regions, the q_e values for quarks can be nonzero because the mixture between the right- $|\boldsymbol{R}_R(+t)\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle$ helicity elements at the time axis as a consequence of any origin (i.e., Higgs boson, broken symmetry of chirality etc.) can occur. Therefore, there are the electric charges as well as the magnetic fields originating from the spin magnetic moments and the magnetic monopoles. Even under no external applied magnetic and electric fields, there are electric and magnetic fields in nearly one dimension parallel to the bonding axis of two quarks at $r > 10^{-16} \sim 10^{-18}$ [m]. In such a case, there are strong attractive magnetic forces between two quarks and thus two quarks mainly move along the bond axis of two

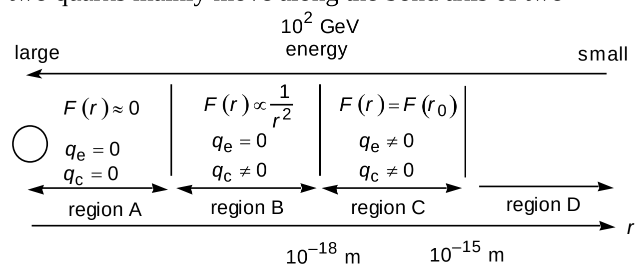

Fig. 8. Electric and magnetic charges as a function of the distance from a quark.

quarks because of the electric and magnetic charges (magnetic monopoles) of two quarks. Therefore, the circulated magnetic field is induced around this axis when the charged quarks move along the bond axis of two quarks (Fig. 9 (c)), according to the Ampère's law. Since the lines of the magnetic forces cannot be crossed by each other, the magnetic fields emitted from the color charges (magnetic monopoles) of quarks are confined in the very small range along the bond axis of two quarks in the one-dimension (Fig. 9 (c)). Furthermore, because of very sharp confinement of the lines of magnetic forces in one-dimension, the gluons are always exchanged between two quarks within a very small range along the bond axis of two quarks in the one-dimension. Therefore, the gluons also cannot escape from hadrons (Fig. 9 (c)). We can also consider as follows. In general, electrically charged particles tend to move along the strong magnetic fields. In this case, the electromagnetic states are the most stable when the electric and magnetic fields are directed to the same direction parallel to the bonding axis of two quarks. Therefore, the magnetic field is confined within nearly one-dimension. This is the reason why the strengths of the magnetic fields do not change with an increase in the r value, and this is the reason why the strengths of the strong forces originating mainly from the magnetic forces are constant at $r > 10^{-16} \sim 10^{-18}$ [m]. Furthermore, this is the reason why the quarks and gluons are confined within a hadron (Fig. 9 (c)).

At $r > 10^{-15}$ [m] (region D) (Fig. 8), the amount of work done against a force $F(r_0)$ is enough to create particle–antiparticle pairs within a very short distance of an interaction. In simple terms, the very energy applied to pull two quarks apart will create a pair of new quarks that will pair up with the original ones. The failure of all experiments that have searched for free quarks is considered to be evidence for this phenomenon. This can be understood as follows. Because of the very sharp confinement of the lines of the magnetic forces within the one-dimension, the strong forces do not diminish with an increase in distance (Figs. 8 and 9 (c)). Therefore, the amount of work done against the constant strong force

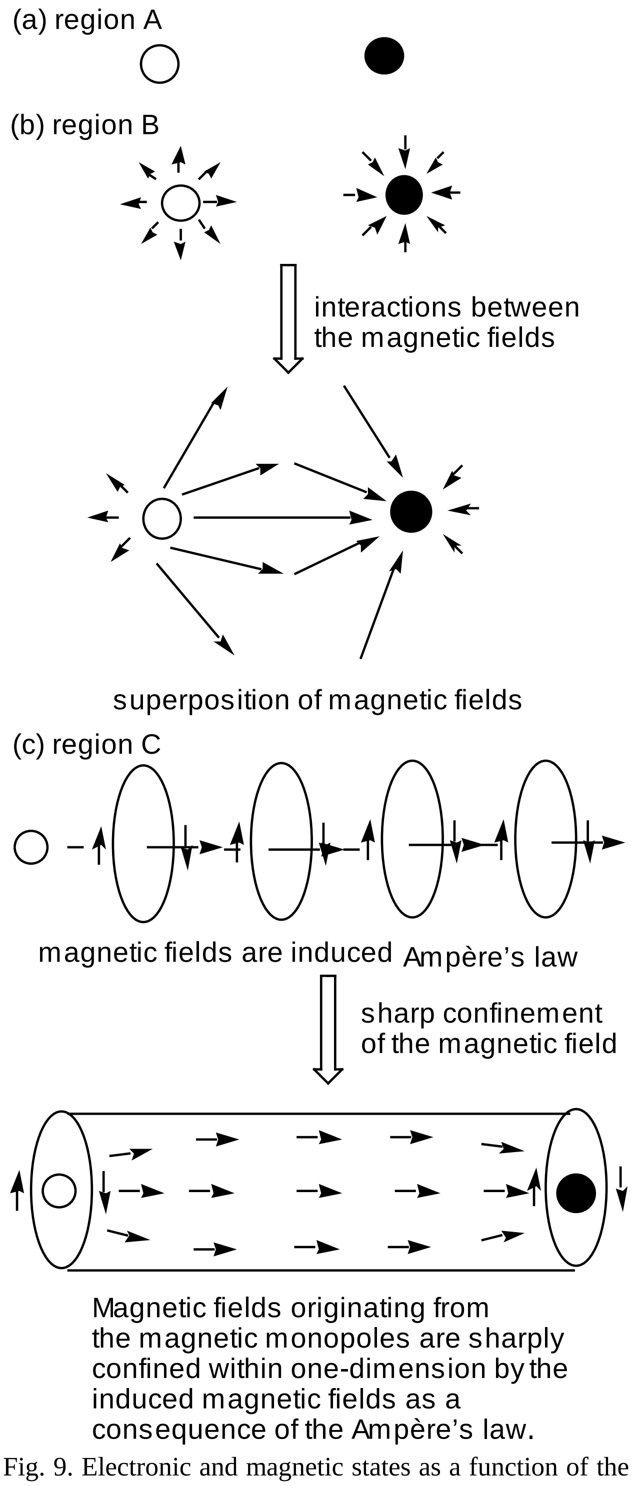

Fig. 9. Electronic and magnetic states as a function of the distance from a quark.

$F(r_0)$ is enough to create particle–antiparticle pairs within a short distance of an interaction. That is, the strong force becomes very strong because of the sharp confinement of the lines of the magnetic forces between

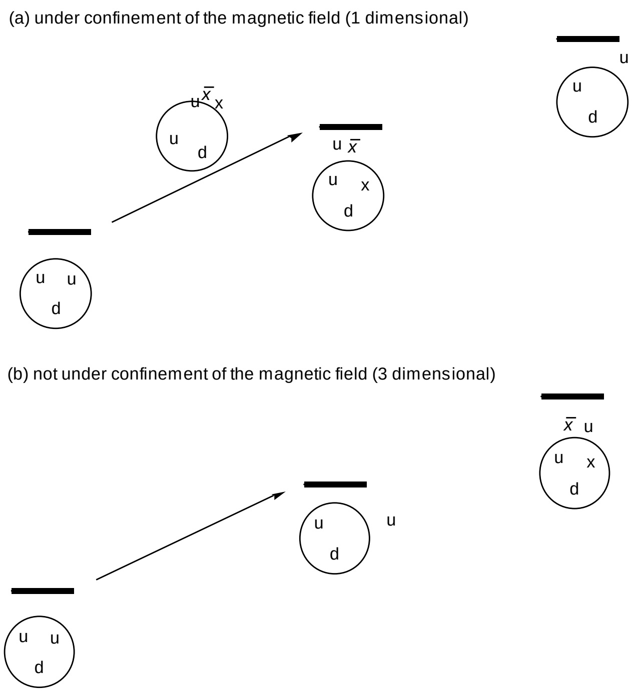

Fig. 10. Energy diagram for the quark-quark interactions.

two quarks, and thus the quark–antiquark pair production energy is reached before quarks can be separated (Fig. 10 (a)). If there were not the magnetic monopoles in quarks, the confinement of the lines of the magnetic forces would not occur, and thus the strong force would be much weaker than actually it is. If the strong force were much weaker, quarks could be separated before the quark–antiquark pair production energy is reached (Fig. 10 (b)). Therefore, the existence of the magnetic monopole as well as the electric charge in quark, generating one-dimensional very strong force, is the main reason why the confinement of the quarks and gluons within hadron can be observed.

When the distance (r) between two quarks is very short (shorter than about $10^{-16} \sim 10^{-18}$ $[\mathrm{m}]$) (region B) (Fig. 9 (b)), the strong force between two quarks is inversely proportional to the r^2 values. This can be understood as follows. At $r << 10^{-18}$ $[\mathrm{m}]$, that is, at very high energy regions, the q_{e} values for quarks can be zero because the mixture between the right- $|\boldsymbol{R}_R(+t)\rangle\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle\rangle$ helicity elements at the time axis as a consequence of any origin (i.e., Higgs boson, broken symmetry of chirality etc.) cannot occur. Therefore, there are only the magnetic fields originating from the spin magnetic moments and the magnetic monopoles. In such a case, each magnetic monopole emits magnetic fields spherically at three dimensions (Fig. 9 (b)). Therefore, the strengths of the magnetic fields are inversely proportional to the r^2 values. Furthermore, the magnetic fields from two or three quarks are synthesized, according to the principle of the superposition of the magnetic fields in electromagnetism. This is the reason why the strengths of the strong forces originating from the magnetic forces are inversely proportional to the r^2 values.

When the distance (r) between two quarks is extremely short (much shorter than about 10^{-18} $[\mathrm{m}]$) (region A) (Fig. 8), it appears to exert little force so that the quarks are like free particles within the confining boundary of the color force and only experience the strong confining force when they begin to get too apart. This can be understood as follows. At $r << 10^{-18}$ $[\mathrm{m}]$, that is, at extremely high energy regions, the q_{c} values as well as the q_{e} values for quarks can be zero because the mixture between the right- $|\boldsymbol{R}_R(+t)\rangle\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle\rangle$ helicity elements at the time axis as a consequence of any origin (i.e., Higgs boson, broken symmetry of chirality etc.) cannot occur. Therefore, there are no magnetic fields originating from the magnetic monopoles. Therefore, in such a case, there can be no strong force. This is the reason why it appears to exert little force so that the quarks are like free particles within the confining boundary of the color force.

In summary, one-dimensional property of the strong force in the range of $10^{-15} \sim 10^{-18}$ $[\mathrm{m}]$ can be explained by the fact that the magnetic field originating from the magnetic monopole (color charge) are confined within the one-dimension by the induced magnetic fields as a consequence of the electric field originating from the electric charge, according to the Ampère's law. The magnetic field is confined within nearly one-dimension. This effect is also observed in the phenomenon of aurora; electric charged particles tend to move along the strong magnetic fields.

There is a possibility that we can observe the properties of the magnetic monopoles if the free quarks are isolated.

4.3 Spin Magnetic Moment in Proton

According to the experimental results for the spin of proton, only 30 % of the spin magnetic moment in proton originates from those in three quarks. On the other hand, according to our theory, there are magnetic monopoles in quarks. Therefore, there is a possibility that the actual spin magnetic moment for the quarks with magnetic monopoles in our theory are much larger than that without magnetic monopoles in the QCD theory. That is, according to our theory, there is a possibility that the spin magnetic moment for a proton can be fully explained by the summation of the spin magnetic moments for quarks with the magnetic monopoles.

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4.4 Unified Interpretations of the Electric, Magnetic, Gravitational, and Strong Forces

Let us next look into the unified interpretations of the electric, magnetic, gravitational, and strong forces (Table 1).

The spin magnetic charge energy for the spin magnetic forces can be expressed by the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k}) \middle| H_{0,+\boldsymbol{k},+\boldsymbol{k}} \middle| \boldsymbol{R}_R(+\boldsymbol{k}) \right\rangle$ and $\left\langle \boldsymbol{R}_L(+\boldsymbol{k}) \middle| H_{0,+\boldsymbol{k},+\boldsymbol{k}} \middle| \boldsymbol{R}_L(+\boldsymbol{k}) \right\rangle$ terms. That is, the spin magnetic charges for the magnetic forces can be explained to be the difference of the angular momentum between the right- and left-handed chirality at the space axis (Table 1).

The color charge energy for the strong forces can be expressed by the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ term (magnetic monopole). That is, two of three color charges for the strong forces can be explained to be the angular momentum at the time axis, and one of three color charges for the strong force can be explained to be the spin magnetic angular momentum at the space axis.

The massive charge energy for the gravitational forces can be expressed by the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k}) \middle| H_{1,+\boldsymbol{k},-\boldsymbol{k}} \middle| \boldsymbol{R}_L(-\boldsymbol{k}) \right\rangle$ term. That is, the massive charges for the gravitational forces can be explained to be the cancellation as a consequence of the mixture of the angular momentum for the right- and left-handed helicity elements at the space axis (Table 1).

The electric charge energy for the electric forces can be expressed by the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ term. That is, the electric charges for the electric forces can be explained to be the angular momentum at the time axis (Table 1).

Considering that the gravitational forces can be interpreted as the residual electromagnetic forces, the three electric charges for the electric forces can be expressed as the electric terms of the $\left\langle \boldsymbol{R}_R(+\boldsymbol{k}) \middle| H_{1,+\boldsymbol{k},-\boldsymbol{k}} \middle| \boldsymbol{R}_L(-\boldsymbol{k}) \right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k}) \middle| H_{1,+\boldsymbol{k},-\boldsymbol{k}} \middle| \boldsymbol{L}_R(-\boldsymbol{k}) \right\rangle$ terms, the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ terms, and the $\left\langle \boldsymbol{L}_L(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{L}_L(+t) \right\rangle$ terms.

Table 1. Type of axis at which each charge exists.

charge	electric (H_1)	magnetic (H_0)
$+q_{\mathrm{m}}$, $-q_{\mathrm{m}}$	—	space
$\pm q_{\mathrm{c}}$	—	space
q_{g}	space	(space)
$+q_{\mathrm{e}}$, $-q_{\mathrm{e}}$	time	—
$+q_{\mathrm{c}}$, $-q_{\mathrm{c}}$	—	time

4.5 Relationships between the Gauge Bosons in the Electric, Magnetic, and Strong Forces

According to our research, it is natural to consider that the γ_{c} boson as well as the γ_{e} and γ_{m} bosons play a role in the same forces. That is, it is natural to consider that the strong force is closely related to the electric force, magnetic force, and electromagnetic force. That is, even though we cannot decide at the moment that the gluon is a kind of photons, there is a possibility that the gluon is closely related to the photons (Fig. 11).

We can consider that the gauge photonic particle medium (γ) for electric forces (γ_{e}), magnetic forces (γ_{m}), and strong force (γ_{c}), which originate from the angular momentum at the space and time axes, were essentially the same at the Big Bang. We can consider that the photon γ , which plays a role in the electric force, is observed as the medium of the electric field γ_{e} , the photon γ , which plays a role in the magnetic force, is observed as the medium of the magnetic field γ_{m} , and the photon γ , which plays a role in the strong force, is observed as the medium of the gravitational field (graviton) γ_{c} (Fig. 11).

We do not completely know whether the substance of the strong force is directly related to that of the electromagnetic forces at the moment. On the other hand, we can at least say that the element of the strong force is generated by the right- and left-handed helicity elements of the magnetic angular momentum, and furthermore, is closely related to the magnetic monopole. There is a possibility that the color field, the electric field, and magnetic field, which are observed as a consequence of the exchange of the three kinds of bosons (gluon (γ_{c}) and photon (γ_{e} , γ_{m})), are generated originally from the same gauge boson (γ) (Fig. 11). That is, there is a possibility that we observe γ as gluon (γ_{c}) in the generation of the strong force, we observe γ as electric photon (γ_{e}) in the generation of the electric force, and we observe γ as magnetic photon (γ_{m}) in the generation of the magnetic force.

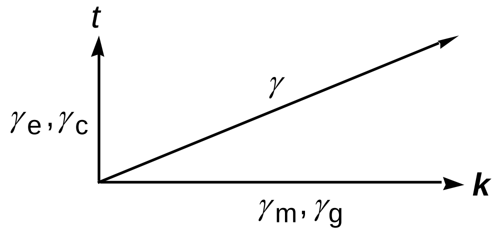

Fig. 11. Relationships between the gauge bosons for the electromagnetic, magnetic, gravitational, electric, and strong forces at the space and time axes.

5. Concluding Remarks

In this research, we discussed the origin of the strong forces, by comparing the strong force with the gravitational, electric, magnetic, and electromagnetic forces. We also discussed the essential properties of the gluon and color charges. Furthermore, we also discussed the reason why the quarks and gluons are confined in hadron.

According to the quantum chromodynamics (QCD), it has been considered that the strong force is observed as a consequence of the exchange of gluon between two quarks. However, the essential properties of the color charge and gluon have not been elucidated in detail. That is, the reason why the strong force is observed as a consequence of the exchange of gluon between two quarks has not been elucidated. We discussed the mechanism how the quarks emit and absorb gluon and how the strong force is generated as a consequence of this process. We also discussed how the gluon in the strong force is related to the photon in electromagnetic force.

We can consider that the color charges are closely related to the magnetic fields (the magnetic monopole and the spin magnetic moment). We can consider that magnetic monopole is the right- $|\boldsymbol{R}_R(+t)\rangle$ and left-handed $|\boldsymbol{R}_L(-t)\rangle$ handed helicity elements of the angular momentum in quark at the time axis. The total chirality in the $\langle \boldsymbol{R}_R(+t)|H_{0,+t,+t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle \boldsymbol{L}_L(+t)|H_{0,+t,+t}|\boldsymbol{L}_L(+t)\rangle$ values in the both $|\boldsymbol{R}\uparrow(q_e,+t)\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle$ states are not zero, and opposite by each other, and the number of elements for color charge at time axis is two. On the other hand, the number of elements for color charge at space axis is one. Furthermore, there is only attractive forces between two or three color charges.

We look into the origin of the strong force. According to our theory, quarks can have the magnetic monopoles, and leptons do not have the magnetic monopoles. This is the reason why we usually observe that quarks have the color charges while the leptons do not have color charges.

The color charges can be closely related to the spin magnetic moments and magnetic monopoles. That is, we can expect that the spin magnetic moments and the magnetic monopoles in quarks emit and absorb the photon (electromagnetic waves) called gluon. Therefore, the gluon can be considered to be a kind of photon emitted and absorbed by quarks. That is, we can consider that the strong forces can be generated because the photons (electromagnetic waves) called gluons emitted and absorbed by the spin magnetic moment and the magnetic monopoles called color charges in quarks are exchanged between quarks.

The strong force between two or three quarks and anti-quarks is always attractive. This can be understood as follows. The total color charge (total external magnetic charge) must be 0 (white) ($q_{c,\text{total}} = q_{c,R} + q_{c,B} + q_{c,G} = 0$) when the particle is very stable. When the total color charges in two or three quarks are 0 (white), the total magnetic charge within a hadron becomes 0. In such a case, the attractive interactions between the N and S magnetic monopoles can become strong and thus the magnetic states can be very stable. On the other hand, if the total color charges in two or three quarks are not zero (red, blue, or green), the repulsive interactions between the N and N (or S and S) magnetic monopoles can become strong and thus the magnetic states can be very unstable. This is the reason why the total color charge (total external magnetic charge) must be 0 (white) ($q_{c,\text{total}} = q_{c,R} + q_{c,B} + q_{c,G} = 0$) when the particle is very stable.

The strong force $F(r)$ values become constant if the r value is larger than $10^{-16} \sim 10^{-18}$ [m], and those are inversely proportional to the r^2 values if the r value is smaller than $10^{-16} \sim 10^{-18}$ [m].

When the distance (r) between the two quarks is relatively large (longer than about $10^{-16} \sim 10^{-18}$ [m]), the strong force between two quarks does not change with an increase in the r value. This can be understood as follows. At $r > 10^{-16} \sim 10^{-18}$ [m], that is, at relatively low energy regions, the q_e values for quarks can be nonzero. Therefore, there are the electric charges as well as the magnetic fields originating from the spin magnetic moments and the magnetic monopoles. Even under no external applied magnetic and electric fields, there are electric and magnetic fields in nearly one dimension parallel to the bonding axis of two quarks at $r > 10^{-16} \sim 10^{-18}$ [m]. In such a case, there are strong attractive magnetic forces between two quarks and thus two quarks mainly move along the bond axis of two quarks because of the electric and magnetic charges (magnetic monopoles) of two quarks. Therefore, the circulated magnetic field is induced around this axis when the charged quarks move along the bond axis of two quarks, according to the Ampère's law. Since the lines of the magnetic forces cannot be crossed by each other, the magnetic fields emitted from the color charges (magnetic monopoles) of quarks are confined in the very small range along the bond axis of two quarks in the one-dimension. Furthermore, because of very sharp confinement of the lines of magnetic forces in one-dimension, the gluons are always exchanged between two quarks within a very small range along the bond axis of two quarks in the one-dimension. Therefore, the gluons also cannot escape from hadrons. This is the reason why the quarks and gluons are confined within a hadron.

At $r > 10^{-15}$ [m], the amount of work done against a force $F(r_0)$ is enough to create particle–antiparticle pairs within a very short distance of an interaction. In simple terms, the very energy applied to pull two quarks apart will create a pair of new quarks that will pair up with the original ones. The failure of all experiments that have searched for free quarks is considered to be evidence for this phenomenon. This can be understood as follows. Because of the very sharp confinement of the lines of the magnetic forces within the one-dimension, the strong forces do not diminish with an increase in distance. Therefore, the amount of work done against the constant strong force $F(r_0)$ is enough to create particle–antiparticle pairs within a short distance of an interaction. That is, the strong force becomes very strong because of the sharp confinement of the lines of the magnetic forces between two quarks, and thus the quark–antiquark pair production energy is reached before quarks can be separated. If there were not the magnetic monopoles in quarks, the confinement of the lines of the magnetic forces would not occur, and thus the strong force would be much weaker than actually it is. If the strong force were much weaker, quarks could be separated before the quark–antiquark pair production energy is reached. Therefore, the existence of the magnetic monopole as well as the electric charge in quark, generating one-dimensional very strong force, is the main reason why the confinement of the quarks and gluons within hadron can be observed.

When the distance (r) between two quarks is very short (shorter than about $10^{-16} \sim 10^{-18}$ [m]), the strong force between two quarks is inversely proportional to the r^2 values. This is because there are only the magnetic fields originating from the spin magnetic moments and the magnetic monopoles. In such a case, each magnetic monopole emits magnetic fields spherically at three dimensions. This is the reason why the strengths of the strong forces originating from the magnetic forces are inversely proportional to the r^2 values.

When the distance (r) between two quarks is extremely short (much shorter than about 10^{-18} [m]), it appears to exert little force so that the quarks are like free particles within the confining boundary of the color force. This is because there are no magnetic fields originating from the magnetic monopoles. Therefore, in such a case, there can be no strong force. This is the reason why it appears to exert little force so that the quarks are like free particles within the confining boundary of the color force.

In summary, one-dimensional property of the strong force in the range of $10^{-15} \sim 10^{-18}$ [m] can be explained by the fact that the magnetic field originating from the magnetic monopole (color charge) are confined within the one-dimension by the induced magnetic fields as a consequence of the electric field originating from the electric charge, according to the Ampère's law.

There is a possibility that we can observe the properties of the magnetic monopoles if the free quarks are isolated.

The color charge energy for the strong forces can be expressed by the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ term (magnetic monopole). That is, two of three color charges for the strong forces can be explained to be the angular momentum at the time axis, and one of three color charges for the strong force can be explained to be the spin magnetic angular momentum at the space axis.

We do not completely know whether the substance of the strong force is directly related to that of the electromagnetic forces at the moment. On the other hand, we can at least say that the element of the strong force is generated by the right- and left-handed helicity elements of the magnetic angular momentum, and furthermore, is closely related to the magnetic monopole. There is a possibility that the color field, the electric field, and magnetic field, which are observed as a consequence of the exchange of the three kinds of bosons (gluon (γ_c) and photon (γ_e, γ_m)), are generated originally from the same gauge boson (γ). That is, there is a possibility that we observe γ as gluon (γ_c) in the generation of the strong force, we observe γ as electric photon (γ_e) in the generation of the electric force, and we observe γ as magnetic photon (γ_m) in the generation of the magnetic force.

Acknowledgments

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References

[1] T. Kato, “Diamagnetic currents in the closed-shell electronic structures in sp^3-type hydrocarbons” Chemical Physics, vol. 345, 2008, pp. 1–13.
[2] T. Kato, “The essential role of vibronic interactions in electron pairing in the micro- and macroscopic sized materials” Chemical Physics, vol. 376, 2010, pp. 84–93.
[3] T. Kato, “The role of phonon- and photon-coupled interactions in electron pairing in solid state materials” Synthetic Metals, vol. 161, 2011, pp. 2113–2123.
[4] T. Kato, “New Interpretation of the role of electron-phonon interactions in electron pairing in superconductivity” Synthetic Metals, vol. 181, 2013, pp. 45–51.
[5] T. Kato, “Relationships between the intrinsic properties of electrical currents and temperatures” Proceedings of Eleventh TheIIER International Conference, February 2015, Singapore, pp. 63–68.
[6] T. Kato, “Relationships between the nondissipative diamagnetic currents in the microscopic sized atoms and molecules and the superconductivity in the macroscopic sized solids” Proceedings of Eleventh TheIIER International Conference, February 2015, Singapore, pp. 69–80.
[7] T. Kato, “Vibronic stabilization under the external applied fields” Proceedings of Eleventh TheIIER International Conference, February 2015, Singapore, pp. 110–115.
[8] T. Kato, K. Yoshizawa, and K. Hirao, “Electron-phonon coupling in negatively charged acene- and phenanthrene-edge-type hydrocarbons” J. Chem. Phys. vol. 116, 2002, pp. 3420-3429.
[9] R. Mitsuhashi, Y. Suzuki, Y. Yamanari, H. Mitamura, T. Kambe, N. Ikeda, H. Okamoto, A. Fujiwara, M. Yamaji, N. Kawasaki, Y. Maniwa, and Y. Kubozono, “Superconductivity in alkali-metal-doped picene” Nature vol. 464, 2010, pp. 76-79.
[10] T. Kato, “Electronic Properties under the External Applied Magnetic Field in the Normal Metallic and Superconducting States” Int. J. Sci. Eng. Appl. Sci., vol. 1, Issue 7, 2015, pp.300-320.
[11] T. Kato, “Electron–Phonon Interactions under the External Applied Electric Fields in the Normal Metallic and Superconducting States in Various Sized Materials” Int. J. Sci. Eng. Appl. Sci., vol. 1, Issue 8, 2015, pp.1-16.
[12] M. Murakami, Chodendo Shin-Jidai (New Era for Research of Superconductivity), Kogyo-Chosa-kai, Tokyo, 2001 (in Japanese).
[13] T. Kato, “Relationships between the Electric and Magnetic Fields” Int. J. Sci. Eng. Appl. Sci., vol. 1, Issue 9, 2015, pp.128-139.
[14] T. Kato, “Unified Interpretation of the Gravitational, Electric, Magnetic, and Electromagnetic Forces” Int. J. Sci. Eng. Appl. Sci., vol. 2, Issue 1, 2016, pp.153-165.

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