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Higgs Mechanism in Superconductivity and Weak Interactions

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Abstract

The weak isospin charges are the magnetic charges (the magnetic monopole at time axis and the spin magnetic moment at space axis). The confinement of the strong forces is not perfect. Therefore, the weak bosons are magnetic fields of the superposition of the magnetic monopole and the induced spin magnetic moment originating from the Ampère's law in quarks and antiquarks in hadron and vacuum, within the 10^{-18} m from the bonding axis of the neighboring two quarks and antiquarks. The weak forces can be generated because the photons (magnetic fields) called weak bosons, which are emitted from quarks and antiquarks and absorbed by quarks, antiquarks, leptons, and anti-leptons (the spin magnetic moment and the magnetic monopoles), are exchanged between quarks, antiquarks, leptons, and anti-leptons. The reason why the parity violation can be observed in the weak interactions is also discussed.

Keywords: Weak Isospin Charge; Magnetic Monopole; Meissner Effects; Nambu–Goldstone Boson; Weak Bosons.

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, 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]. 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 [15].

In this research, we will discuss the origin of the weak forces, by comparing the weak force with the gravitational, electric, magnetic, strong, and electromagnetic forces. We will also discuss the essential properties of the weak bosons and weak isospin charges. Furthermore, we will also discuss the reason why the parity violation can be observed in the weak interactions.

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, of the strong force (color charge), and of the weak force (weak isospin charge) are denoted as q_{g}, q_{e}, q_{m}, q_{em}, q_{c}, and q_{w}, respectively (Figs. 1–4). 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), of the strong force (gluon), and of the weak force (weak photonic boson) are denoted as γ_{g}, γ_{e}, γ_{m}, γ_{em}, γ_{c}, and γ_{w}, 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

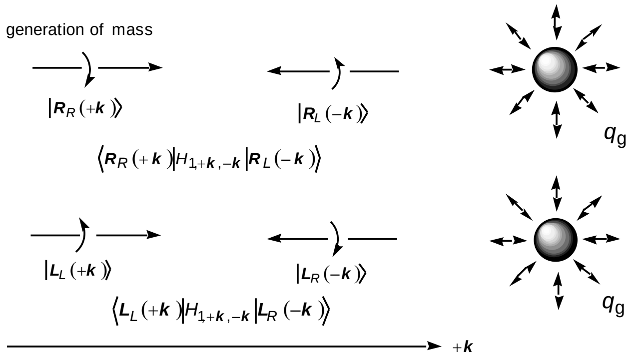

Fig. 1. Origin of massive charge.

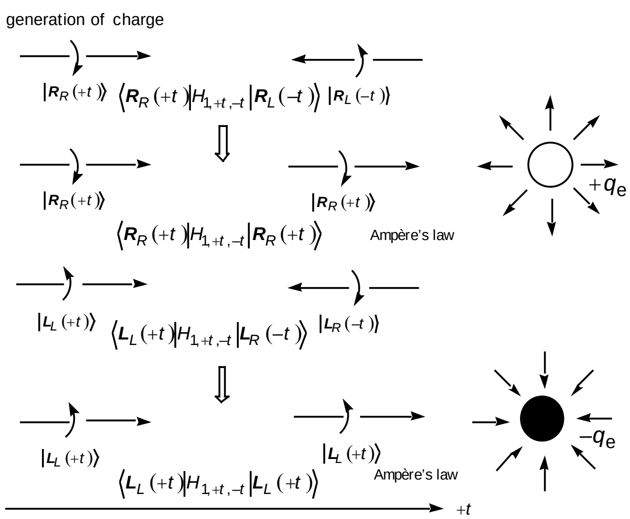

Fig. 2. Origin of electric charge.

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,

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

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

where the $|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and $|\boldsymbol{R}_L(-\boldsymbol{k})\rangle$ denote the right- and left-handed helicity elements in the right-handed chirality $\left|\boldsymbol{R}\uparrow\left(q_{\mathrm{g}}\right)\right\rangle$ state, respectively, and the $|\boldsymbol{L}_L(+\boldsymbol{k})\rangle$ and $|\boldsymbol{L}_R(-\boldsymbol{k})\rangle$ denote the left- and right-handed helicity elements in the left-handed chirality $\left|\boldsymbol{L}\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ state, respectively, at the space axis. By considering the

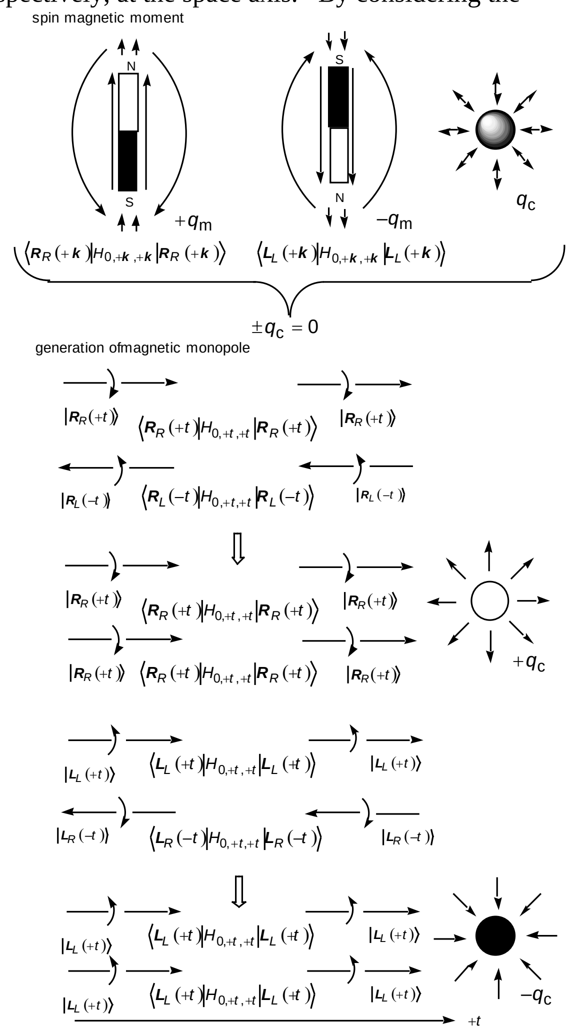

Fig. 3. Origin of spin magnetic moment and color charge (magnetic monopole).

normalizations of the $\left|\boldsymbol{R}\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ and $\left|\boldsymbol{L}\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ 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

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

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

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 $\left|\boldsymbol{R}\uparrow(q_{\rm g},\boldsymbol{k})\right\rangle$ state can be estimated as

$$\begin{aligned}
&\left\langle \boldsymbol{R}\uparrow(q_{\rm g},\boldsymbol{k})\right| H_{\boldsymbol{k}} \left|\boldsymbol{R}\uparrow(q_{\rm g},\boldsymbol{k})\right\rangle \\
&= \left(2c_{\boldsymbol{R}_R}^2(q_{\rm g})-1\right)\varepsilon_{q_{\rm m\infty},\boldsymbol{R}} + 2c_{\boldsymbol{R}_R}(q_{\rm g})\sqrt{1-c_{\boldsymbol{R}_R}^2(q_{\rm g})}\,\varepsilon_{q_{\rm g\infty},\boldsymbol{R}} \\
&= \varepsilon_{q_{\rm m},\boldsymbol{R}}(q_{\rm g}) + \varepsilon_{q_{\rm g},\boldsymbol{R}}(q_{\rm g})
\end{aligned} \tag{6}$$

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

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

and the $\varepsilon_{q_{\rm g\infty},\boldsymbol{R}}$ 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,

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

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

$$\varepsilon_{q_{\rm g},\boldsymbol{R}}(q_{\rm g}) = 2c_{\boldsymbol{R}_R}(q_{\rm g})\sqrt{1-c_{\boldsymbol{R}_R}^2(q_{\rm g})}\,\varepsilon_{q_{\rm g\infty},\boldsymbol{R}}, \tag{9}$$

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

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

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

$$\varepsilon_{q_{\rm m\infty},\boldsymbol{RL}} = \varepsilon_{q_{\rm m\infty},\boldsymbol{R}} + \varepsilon_{q_{\rm m\infty},\boldsymbol{L}} = 0, \tag{11}$$

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

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

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

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

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

$$\varepsilon_{q_{\rm g},\boldsymbol{L}}(q_{\rm g}) = 2c_{\boldsymbol{L}_L}(q_{\rm g})\sqrt{1-c_{\boldsymbol{L}_L}^2(q_{\rm g})}\,\varepsilon_{q_{\rm g\infty},\boldsymbol{L}}, \tag{16}$$

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

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

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 $q_{\rm e}$ can be composed from the right-handed chirality $\left|\boldsymbol{R}\uparrow(q_{\rm e},+t)\right\rangle$ or left-handed chirality $\left|\boldsymbol{L}\downarrow(q_{\rm e},+t)\right\rangle$ elements, defined as,

$$\left|\boldsymbol{R}\uparrow(q_{\rm e},+t)\right\rangle = c_{\boldsymbol{R}_R}(q_{\rm e})\left|\boldsymbol{R}_R(+t)\right\rangle + c_{\boldsymbol{R}_L}(q_{\rm e})\left|\boldsymbol{R}_L(-t)\right\rangle, \tag{19}$$

$$\left|\boldsymbol{L}\downarrow(q_{\rm e},+t)\right\rangle = c_{\boldsymbol{L}_L}(q_{\rm e})\left|\boldsymbol{L}_L(+t)\right\rangle + c_{\boldsymbol{L}_R}(q_{\rm e})\left|\boldsymbol{L}_R(-t)\right\rangle, \tag{20}$$

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 $\left|\boldsymbol{R}\uparrow(q_{\rm e},+t)\right\rangle$ state, respectively, and the $|\boldsymbol{L}_L(+t)\rangle$ and

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

$$\left\langle\!\left\langle \boldsymbol{R}\uparrow(q_e,+t)\right|\boldsymbol{R}\uparrow(q_e,+t)\right\rangle\!\rangle = c_{\boldsymbol{R}_R}^2(q_e) + c_{\boldsymbol{R}_L}^2(q_e) = 1, \quad (21)$$

$$\left\langle\!\left\langle \boldsymbol{L}\downarrow(q_e,+t)\right|\boldsymbol{L}\downarrow(q_e,+t)\right\rangle\!\rangle = c_{\boldsymbol{L}_L}^2(q_e) + c_{\boldsymbol{L}_R}^2(q_e) = 1. \quad (22)$$

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 $\left|\boldsymbol{R}\uparrow(q_e,+t)\right\rangle\!\rangle$ states can be estimated as

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. Relationships between the Spin Magnetic Moment, Massive Charge, Electric Charge, and Color Charge: Towards Application to the Weak Isospin Charge

3.1 Spin Magnetic Moment

The energies for the spin magnetic moment for the $\left|\boldsymbol{R}\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ state can be expressed as Eqs. (7) and (10). At the time of the Big Bang, the $\varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}\left(q_{\mathrm{g}}\right)$ and $\varepsilon_{q_{\mathrm{m}},\boldsymbol{L}}\left(q_{\mathrm{g}}\right)$ values were the maximum. That is, there was no mixture between 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 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- $\left|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ 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 $c_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right)$ value). Similar discussions can be made in the $\left|\boldsymbol{L}\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ state.

We can see from Fig. 3 that the $\varepsilon_{q_{\mathrm{m}},\boldsymbol{R}}\left(q_{\mathrm{g}}\right)$ and $\varepsilon_{q_{\mathrm{m}},\boldsymbol{L}}\left(q_{\mathrm{g}}\right)$ values are not equivalent in the space axis. The total chirality and momentum in the $\left\langle\boldsymbol{R}_R(+\boldsymbol{k})\middle|H_{0,+\boldsymbol{k},+\boldsymbol{k}}\middle|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and $\left\langle\boldsymbol{L}_L(+\boldsymbol{k})\middle|H_{0,+\boldsymbol{k},+\boldsymbol{k}}\middle|\boldsymbol{L}_L(+\boldsymbol{k})\right\rangle$ terms in the both $\left|\boldsymbol{R}\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ and $\left|\boldsymbol{L}\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ 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 $\left\langle\boldsymbol{R}_R(+\boldsymbol{k})\middle|H_{0,+\boldsymbol{k},+\boldsymbol{k}}\middle|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and $\left\langle\boldsymbol{L}_L(+\boldsymbol{k})\middle|H_{0,+\boldsymbol{k},+\boldsymbol{k}}\middle|\boldsymbol{L}_L(+\boldsymbol{k})\right\rangle$ values (Fig. 3),

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

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

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 $\left\langle\boldsymbol{R}_R(+\boldsymbol{k})\middle|H_{0,+\boldsymbol{k},+\boldsymbol{k}}\middle|\boldsymbol{R}_R(+\boldsymbol{k})\right\rangle$ and $\left\langle\boldsymbol{L}_L(+\boldsymbol{k})\middle|H_{0,+\boldsymbol{k},+\boldsymbol{k}}\middle|\boldsymbol{L}_L(+\boldsymbol{k})\right\rangle$ 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),

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

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

3.2 Mass

The mass energy $\varepsilon_{q_{\mathrm{g}},\boldsymbol{R}}\left(q_{\mathrm{g}}\right)$ for the right-handed chirality $\left|\boldsymbol{R}\uparrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ element can be defined as Eqs. (8) and (9). At the time of the Big Bang, the $\varepsilon_{q_{\mathrm{g}},\boldsymbol{R}}\left(q_{\mathrm{g}}\right)$ value was the minimum ($c_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right)=1$). 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 $c_{\boldsymbol{R}_R}\left(q_{\mathrm{g}}\right)$ value). Similar discussions can be made in the $\left|\boldsymbol{L}\downarrow\left(q_{\mathrm{g}},\boldsymbol{k}\right)\right\rangle$ state.

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

$$\varepsilon_{q_{\mathrm{g}},\boldsymbol{R}}\left(q_{\mathrm{g}}\right)=\varepsilon_{q_{\mathrm{g}},\boldsymbol{L}}\left(q_{\mathrm{g}}\right)$$

$$= k_{q_g} \langle \boldsymbol{R}_R(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{R}_L(-\boldsymbol{k}) \rangle$$
$$= k_{q_g} \langle \boldsymbol{L}_L(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{L}_R(-\boldsymbol{k}) \rangle. \qquad (39)$$

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 $\langle \boldsymbol{R}_R(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{R}_L(-\boldsymbol{k}) \rangle$ and $\langle \boldsymbol{L}_L(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{L}_R(-\boldsymbol{k}) \rangle$ terms in the both $|\boldsymbol{R}\uparrow(q_g,\boldsymbol{k})\rangle$ and $|\boldsymbol{L}\downarrow(q_g,\boldsymbol{k})\rangle$ states are zero. We can consider that the mass is generated by the mixture of the right- $|\boldsymbol{R}_R(+\boldsymbol{k})\rangle$ and left- $|\boldsymbol{R}_L(-\boldsymbol{k})\rangle$ 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 $\langle \boldsymbol{R}_R(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{R}_L(-\boldsymbol{k}) \rangle$ and $\langle \boldsymbol{L}_L(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{L}_R(-\boldsymbol{k}) \rangle$ 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 $\langle \boldsymbol{R}_R(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{R}_L(-\boldsymbol{k}) \rangle$ and $\langle \boldsymbol{L}_L(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{L}_R(-\boldsymbol{k}) \rangle$ 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 ($\varepsilon_{q_g,\text{external},\boldsymbol{R}}(q_g)$ and $\varepsilon_{q_g,\text{external},\boldsymbol{L}}(q_g)$) for the $\langle \boldsymbol{R}_R(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{R}_L(-\boldsymbol{k}) \rangle$ and $\langle \boldsymbol{L}_L(+\boldsymbol{k}) | H_{1,+\boldsymbol{k},-\boldsymbol{k}} | \boldsymbol{L}_R(-\boldsymbol{k}) \rangle$ 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 $|\boldsymbol{R}\uparrow(q_e,+t)\rangle$ 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 ($c_{\boldsymbol{R}_R}(q_e)=1$). 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 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- $|\boldsymbol{R}_R(+t)\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle$ 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 a decrease in the $c_{\boldsymbol{R}_R}(q_e)$ value). Similar discussions can be made in the $|\boldsymbol{L}\downarrow(q_e,+t)\rangle$ 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 $|\boldsymbol{R}\uparrow(q_e,+t)\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle$ 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 $|\boldsymbol{R}\uparrow(q_e,+t)\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle$ 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 $\left\langle \boldsymbol{R}_R(+\boldsymbol{k}) \middle| H_{1,+\boldsymbol{k},-\boldsymbol{k}} \middle| \boldsymbol{R}_L(-\boldsymbol{k}) \right\rangle$ and $\left\langle \boldsymbol{L}_L(+\boldsymbol{k}) \middle| H_{1,+\boldsymbol{k},-\boldsymbol{k}} \middle| \boldsymbol{L}_R(-\boldsymbol{k}) \right\rangle$ values 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 $\left\langle \boldsymbol{L}_L(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{L}_L(+t) \right\rangle$ state instead of the $\left\langle \boldsymbol{L}_L(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{L}_R(-t) \right\rangle$ state. This is the reason why the total chirality in the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ and $\left\langle \boldsymbol{L}_L(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{L}_L(+t) \right\rangle$ 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 electric charge is two, and thus there are attractive and repulsive forces between two electric charges. Because of the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{R}_R(+t) \right\rangle$ 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 $\left\langle \boldsymbol{L}_L(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{L}_L(+t) \right\rangle$ terms, the electric field only comes into the infinitesimal inlet point from any direction in space and time axes. In summary, because of the $\left\langle \boldsymbol{R}_R(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{R}_L(-t) \right\rangle$ and $\left\langle \boldsymbol{L}_L(+t) \middle| H_{1,+t,-t} \middle| \boldsymbol{L}_R(-t) \right\rangle$ 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 $\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}})$ for the right-handed chirality $\left| \boldsymbol{R} \uparrow (q_{\mathrm{e}}, +t) \right\rangle$ element can be defined as Eqs. (25) and (28). At the time of the Big Bang, the $\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}})$ value was very large ($c_{\boldsymbol{R}_R}(q_{\mathrm{e}}) = 1$). That is, there was no mixture between the right- $\left| \boldsymbol{R}_R(+t) \right\rangle$ and left- $\left| \boldsymbol{R}_{\boldsymbol{L}}(-t) \right\rangle$ 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- $\left| \boldsymbol{R}_R(+t) \right\rangle$ and left- $\left| \boldsymbol{R}_L(-t) \right\rangle$ handed 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 decrease in the $c_{\boldsymbol{R}_R}(q_{\mathrm{e}})$ value). On the other hand, it should be noted that the $\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}})$ value does not change with an increase in time (with decrease in the $c_{\boldsymbol{R}_R}(q_{\mathrm{e}})$ value) Similar discussions can be made in the $\left| \boldsymbol{L} \downarrow (q_{\mathrm{e}}, +t) \right\rangle$ state.

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

$$
\begin{aligned}
&\varepsilon_{q_{\mathrm{c}},\boldsymbol{RL}}(q_{\mathrm{e}}) \\
&= k_{q_{\mathrm{c}},\boldsymbol{RL}} \left\{ c^2_{\boldsymbol{R}_R}(q_{\mathrm{g}}) \left\langle \boldsymbol{R}_R(+\boldsymbol{k}) \middle| H_{0,+\boldsymbol{k},+\boldsymbol{k}} \middle| \boldsymbol{R}_R(+\boldsymbol{k}) \right\rangle \right. \\
&\qquad \left. - c^2_{\boldsymbol{R}_L}(q_{\mathrm{g}}) \left\langle \boldsymbol{R}_L(+\boldsymbol{k}) \middle| H_{0,+\boldsymbol{k},+\boldsymbol{k}} \middle| \boldsymbol{R}_L(+\boldsymbol{k}) \right\rangle \right\} \\
&+ k_{q_{\mathrm{c}},\boldsymbol{RL}} \left\{ c^2_{\boldsymbol{L}_L}(q_{\mathrm{g}}) \left\langle \boldsymbol{L}_L(+\boldsymbol{k}) \middle| H_{0,+\boldsymbol{k},+\boldsymbol{k}} \middle| \boldsymbol{L}_L(+\boldsymbol{k}) \right\rangle \right. \\
&\qquad \left. - c^2_{\boldsymbol{L}_R}(q_{\mathrm{g}}) \left\langle \boldsymbol{L}_R(+\boldsymbol{k}) \middle| H_{0,+\boldsymbol{k},+\boldsymbol{k}} \middle| \boldsymbol{L}_R(+\boldsymbol{k}) \right\rangle \right\} \quad (42)
\end{aligned}
$$

$$
\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}}) = k_{q_{\mathrm{c}},\boldsymbol{R}} \left\langle \boldsymbol{R}_R(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{R}_R(+t) \right\rangle, \qquad (43)
$$

$$
\varepsilon_{q_{\mathrm{c}},\boldsymbol{L}}(q_{\mathrm{e}}) = k_{q_{\mathrm{c}},\boldsymbol{L}} \left\langle \boldsymbol{L}_L(+t) \middle| H_{0,+t,+t} \middle| \boldsymbol{L}_L(+t) \right\rangle. \qquad (44)
$$

On the other hand, the $k_{q_{\mathrm{c}},\boldsymbol{R}}$, $k_{q_{\mathrm{c}},\boldsymbol{L}}$, and $k_{q_{\mathrm{c}},\boldsymbol{RL}}$ 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 $\psi_{q_{\mathrm{c}},\boldsymbol{RL}}(q_{\mathrm{e}})$, $\psi_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}})$, and $\psi_{q_{\mathrm{c}},\boldsymbol{L}}(q_{\mathrm{e}})$ states, having the energies of the $\varepsilon_{q_{\mathrm{c}},\boldsymbol{RL}}(q_{\mathrm{e}})$, $\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}})$, and $\varepsilon_{q_{\mathrm{c}},\boldsymbol{L}}(q_{\mathrm{e}})$, respectively. 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 $\varepsilon_{q_{\mathrm{c}},\boldsymbol{R}}(q_{\mathrm{e}})$, $\varepsilon_{q_{\mathrm{c}},\boldsymbol{L}}(q_{\mathrm{e}})$, and $\varepsilon_{q_{\mathrm{c}},\boldsymbol{RL}}(q_{\mathrm{e}})$ 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. Therefore, we can consider that the color charges in the strong force can originate from the magnetic monopole and the spin magnetic moment.

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,

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

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

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. 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 $\psi_{q_c,\boldsymbol{RL}}(q_e)$ state is 0, and those for the $\psi_{q_c,\boldsymbol{R}}(q_e)$ and $\psi_{q_c,\boldsymbol{L}}(q_e)$ states are N and S magnetic monopoles, respectively.

We can see from Fig. 3 that the $\varepsilon_{q_c,\boldsymbol{R}}(q_e)$ and $\varepsilon_{q_c,\boldsymbol{L}}(q_e)$ values are equivalent in the space axis. The total momentum in the $\langle \boldsymbol{R}_R(+t)|H_{0,+t,+t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle \boldsymbol{L}_L(+t)|H_{0,+t,+t}|\boldsymbol{L}_L(+t)\rangle$ terms in the both $|\boldsymbol{R}\uparrow(q_e,+t)\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle$ states are not zero. And the total chirality in the $\langle \boldsymbol{R}_R(+t)|H_{0,+t,+t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle \boldsymbol{L}_L(+t)|H_{0,+t,+t}|\boldsymbol{L}_L(+t)\rangle$ terms in the $|\boldsymbol{R}\uparrow(q_e,+t)\rangle$ and $|\boldsymbol{L}\downarrow(q_e,+t)\rangle$ 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- $|\boldsymbol{R}_R(+t)\rangle$ and left-handed $|\boldsymbol{R}_L(-t)\rangle$ handed helicity elements of the angular momentum in quark at the time axis. 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 $\langle \boldsymbol{L}_L(+\boldsymbol{k})|H_{1,+\boldsymbol{k},-\boldsymbol{k}}|\boldsymbol{L}_R(-\boldsymbol{k})\rangle$ terms in the both $|\boldsymbol{R}\uparrow(q_g,\boldsymbol{k})\rangle$ and $|\boldsymbol{L}\downarrow(q_g,\boldsymbol{k})\rangle$ 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 $\langle \boldsymbol{R}_R(+t)|H_{0,+t,+t}|\boldsymbol{R}_R(+t)\rangle$ state instead of the $\langle \boldsymbol{R}_L(-t)|H_{0,+t,+t}|\boldsymbol{R}_L(-t)\rangle$ state. This is the reason why 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. Because of the $\langle \boldsymbol{R}_R(+t)|H_{0,+t,+t}|\boldsymbol{R}_R(+t)\rangle$ 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 $\langle \boldsymbol{L}_L(+t)|H_{0,+t,+t}|\boldsymbol{L}_L(+t)\rangle$ 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 $\langle \boldsymbol{R}_R(+t)|H_{0,+t,+t}|\boldsymbol{R}_R(+t)\rangle$ and $\langle \boldsymbol{L}_L(+t)|H_{0,+t,+t}|\boldsymbol{L}_L(+t)\rangle$ terms, originating from 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 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. Weak Isospin Charge, Weak Bosons, and Weak Force

4.1 Strong Force

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 because the mixture between the right- $|\boldsymbol{R}_R(+t)\rangle$ and left- $|\boldsymbol{R}_L(-t)\rangle$ handed 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 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 (Fig. 4), 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-

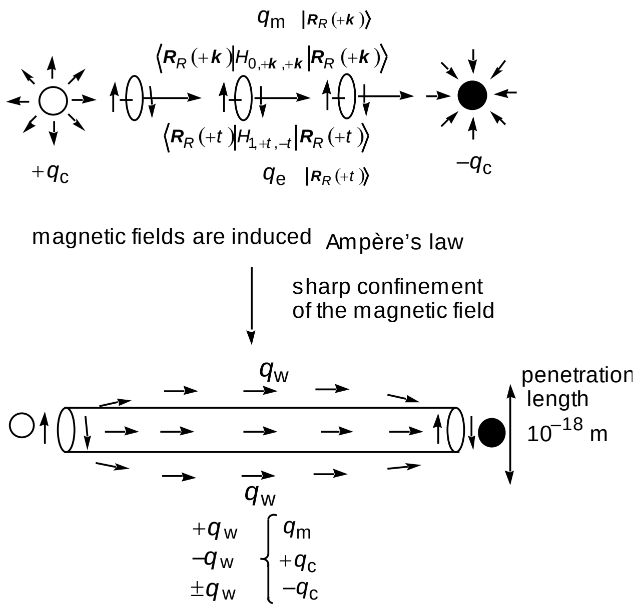

Fig. 4. Origin of weak isospin charge.

dimension (Fig. 4). 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. 4). 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. 4).

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.

4.2 Weak Bosons

Let us next look into the weak bosons ($\gamma_{\rm W}$) (Figs. 4–6). The penetration of the one-dimensional magnetic field into vacuum, originating from the magnetic monopole, is significantly suppressed. On the other hand, the magnetic fields originating from the magnetic monopole can penetrate into the vacuum with a range of 10^{-18} m from the bond axis of two quarks. This phenomenon is essentially the same with the Meissner effects in superconductivity. The fluctuation of the Cooper pairs in the superconductivity is related to the circulated magnetic photon originating from the spin magnetic moment of the moving charged quarks. The induced magnetic field from the one charged particle moving in the Faraday's law and Ampère's law in vacuum are the same with that from the Cooper pair moving (Meissner effect) in the superconductivity. According to the Meissner effect, the expulsion of magnetic fields from the interior of a superconductor can be observed. According to our theory, the exclusion of the magnetic fields originating from the magnetic monopoles in quarks from the interior of the vacuum can be observed.

According to the principle of the superposition of the penetrating one-dimensional magnetic field into vacuum (penetration lengths of about 10^{-18} m) originating from the magnetic monopole, and the circulated magnetic field originating from the spin magnetic moment (Ampère's law), the synthesized helical magnetic fields are generated (Fig. 6). Such synthesized helical magnetic fields are related to the massive weak boson (W^+, W^-, and Z^0), as explained in detail below.

In summary, the weak bosons $\gamma_{\rm W}$ such as W^+, W^-, and Z^0 are the magnetic field as a consequence of superposition of the magnetic fields originating from the massive gluon (γ_c) and the induced circulated spin magnetic fields (γ_m) (Figs. 4 and 6).

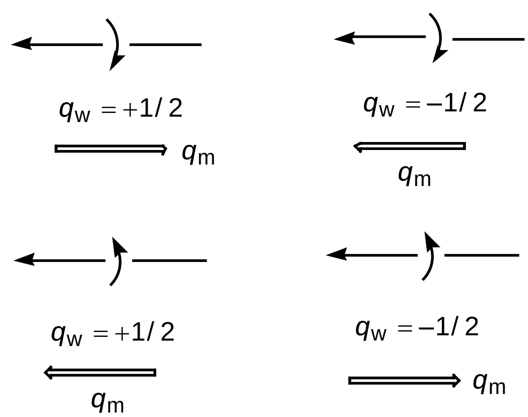

Fig. 5. Relationships between the weak isospin and spin magnetic moment.

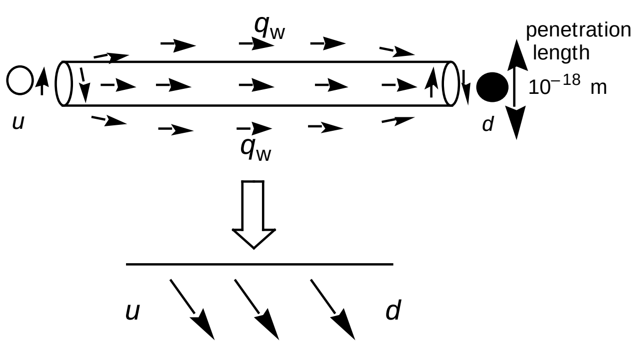

Fig. 6. Synthesized helical magnetic field originating from the magnetic monopoles and the induced spin magnetic moments as a consequence of the Ampère's law.

4.3 Weak Force

The weak isospin charges are the magnetic charges (the magnetic monopole at time axis (Eqs. (25), (26), (31), (32)) and the spin magnetic moment at space axis (Eqs. (7), (14))). 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), as shown in Fig. 4. On the other hand, such confinement is not perfect, and thus the magnetic fields slightly (10^{-18} m) penetrate into vacuum from the bond axis between two neighboring quarks and antiquarks, as shown in Fig. 4. This is very similar to the penetration of the magnetic fields into superconductor in the Meissner effects. In superconductivity, it has been considered that the fluctuation of the Cooper pairs is the origin of the induced circulated magnetic fields (the Higgs mechanism), according to the Ampère's law, by which the magnetic field (magnetic photon) becomes massive in superconductivity. In a similar way, fluctuation of the vibration of the quarks and antiquarks in hadron and vacuum is the origin of the induced circulated magnetic field (the Higgs boson (H^+, H^-, and H^0)), according to the Ampère's law, by which the magnetic fields (weak bosons) become massive in vacuum. Therefore, the weak bosons are magnetic fields of the superposition of the magnetic monopole and the induced spin magnetic moment originating from the Ampère's law in quarks and antiquarks in hadron and vacuum, within the range of 10^{-18} m from the bonding axis of the neighboring two quarks and antiquarks (Fig. 4). The weak forces can be generated because the photons (magnetic fields) called weak bosons, which are emitted from quarks and antiquarks and absorbed by quarks, antiquarks, leptons, and anti-leptons (the spin magnetic moment and the magnetic monopoles), are exchanged between quarks, antiquarks, leptons, and anti-leptons.

4.4 Weak Isospin Charge

One of weak bosons is the massive magnetic photons originating from the $\psi_{q_c,\boldsymbol{R}}(q_e)$ magnetic monopole states. The magnetic photon originating from the $\psi_{q_c,\boldsymbol{R}}(q_e)$ magnetic monopole states become massive because the massless magnetic photon (γ_c) absorbs the Nambu–Goldstone boson called Higgs boson H^+. Such Higgs boson is closely related to the magnetic field originating from the spin magnetic moments of moving charged quark (Ampère's law), by which the penetration of the magnetic field originating from the magnetic monopole (color charge) into the vacuum is suppressed. The penetration length of the W^+ boson into vacuum is about 10^{-18} m. This is very similar to the Meissner effect in superconductivity.

One of weak bosons is the massive magnetic photon originating from the $\psi_{q_c,\boldsymbol{L}}(q_e)$ magnetic monopole states. The magnetic photon originating from the $\psi_{q_c,\boldsymbol{L}}(q_e)$ magnetic monopole state become massive because the massless magnetic photon (γ_c) absorbs the Nambu–Goldstone boson called Higgs boson H^-. Such Higgs boson is closely related to the magnetic field originating from the spin magnetic moments of moving charged quark (Ampère's law), by which the penetration of the magnetic field originating from the magnetic monopole (color charge) into the vacuum is suppressed. The penetration length of the W^- boson into vacuum is about 10^{-18} m. This is very similar to the Meissner effect in superconductivity.

One of weak bosons is the massive magnetic photon originating from the $\psi_{q_c,\boldsymbol{RL}}(q_e)$ spin magnetic states. The magnetic photon originating from the $\psi_{q_c,\boldsymbol{RL}}(q_e)$ spin magnetic and magnetic monopole states become massive because the massless magnetic photon (γ_c) absorbs the Nambu–Goldstone boson called Higgs boson H^0. Such Higgs boson is closely related to the magnetic field originating from the spin magnetic moments of moving charged quark (Ampère's law), by which the penetration of the magnetic field originating from the magnetic monopole (color charge) into the vacuum is suppressed. The penetration length of the Z^0 boson into vacuum is about 10^{-18} m. This is very similar to the Meissner effect in superconductivity.

The W^+, W^-, and Z^0 bosons are the massive magnetic photons originating from the $\psi_{q_c,\boldsymbol{R}}(q_e)$, $\psi_{q_c,\boldsymbol{L}}(q_e)$, and $\psi_{q_c,\boldsymbol{RL}}(q_e)$ magnetic monopole and spin magnetic states, respectively.

The weak isospin charges are the magnetic charges (the magnetic monopole at time axis (Eqs. (25), (26), (31), (32)) and the spin magnetic moment at space axis (Eqs. (7), (14))). That is, the weak isospin charge (q_w) originates from the spin magnetic moments in the quarks and leptons, and from the magnetic monopoles in quarks. The q_w values for the positively and negatively electric charged (q_e) quarks (and antiquarks) are +1/2 and –1/2, respectively, those for the leptons with $q_e = 0$ and $q_e = -1$ are +1/2 and –1/2, respectively, and those for the anti-leptons with $q_e = 0$ and $q_e = +1$ are –1/2 and +1/2, respectively.

The direction of the spin magnetic fields for the left-handed particles (and antiparticles) with $q_w = +1/2$ and $q_w = -1/2$ are the opposite and the same directions, respectively, with respect to the direction of the particles (and antiparticles) moving. Furthermore, the direction of the spin magnetic fields for the right-handed particles (and antiparticles) with $q_w = +1/2$ and $q_w = -1/2$ are the same and the opposite directions, respectively, with respect to the direction of the particles (and antiparticles) moving (Fig. 5).

5. The Decay of Neutron

It has been considered that the weak interaction acts only on the left-handed particles and on the right-handed antiparticles. On the other hand, the reason why the weak interaction acts only on the left-handed particles and on the right-handed antiparticles has not been elucidated.

We will show that the right-handed helicity elements as well as the left-handed helicity elements absorb the weak boson (Figs. 7–10). However, we cannot usually observe weak interactions when weak interaction acts on the right-handed particles and the left-handed antiparticles. We will elucidate the reason why we usually observe the parity violation as a consequence of the weak force.

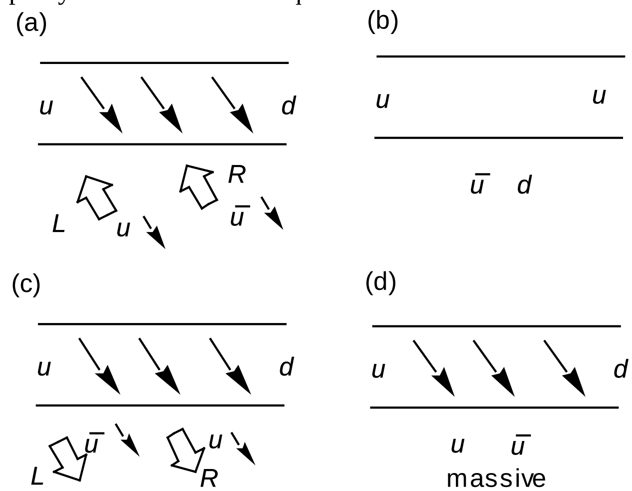

Fig. 7. Decay of neutron. The small arrows indicate the spin magnetic moment, and the large arrows indicate the direction of the particle moving.

5.1 $d \to u + \pi^-$

Let us first consider the decay of neutron ($n \to p + e + \overline{\nu}_e$) (Figs. 7–10). A free neutron will decay by emitting a W^-, which finally produces a proton and a π^- meson.

The strong force becomes very strong because of the sharp confinement of the lines of the magnetic forces between two quarks, and thus the $u - \overline{u}$ pair production energy is reached before u and d quarks in a hadron can be separated (Fig. 7 (a)). In such a case, there is strong magnetic field as a consequence of the penetration of the magnetic field originating from the magnetic monopoles of u and d quarks into the vacuum within the range of 10^{-18} m from the bond axis of the two u and d quarks. This strong magnetic field can be considered as massive W^- boson, which can move within the range of 10^{-18} m from the bonding axis of the two u and d quarks. Now, strong magnetic fields go from the u quark (N pole) to the d quark (S pole). It should be noted that there are right-handed helicity elements as well as the left-handed helicity elements in all massive particles, and there are left-handed helicity elements as well as the right-handed helicity elements in all massive antiparticles. On the other hand, it has been considered that the weak interaction acts only on left-handed particles and right-handed antiparticles.

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Let us first look into the case where the weak interaction acts on the left-handed particles and the right-handed antiparticles (Fig. 7 (a), (b)).

If u quark in the $u-\bar{u}$ pair comes into the small region and feels the strong magnetic fields, and the weak

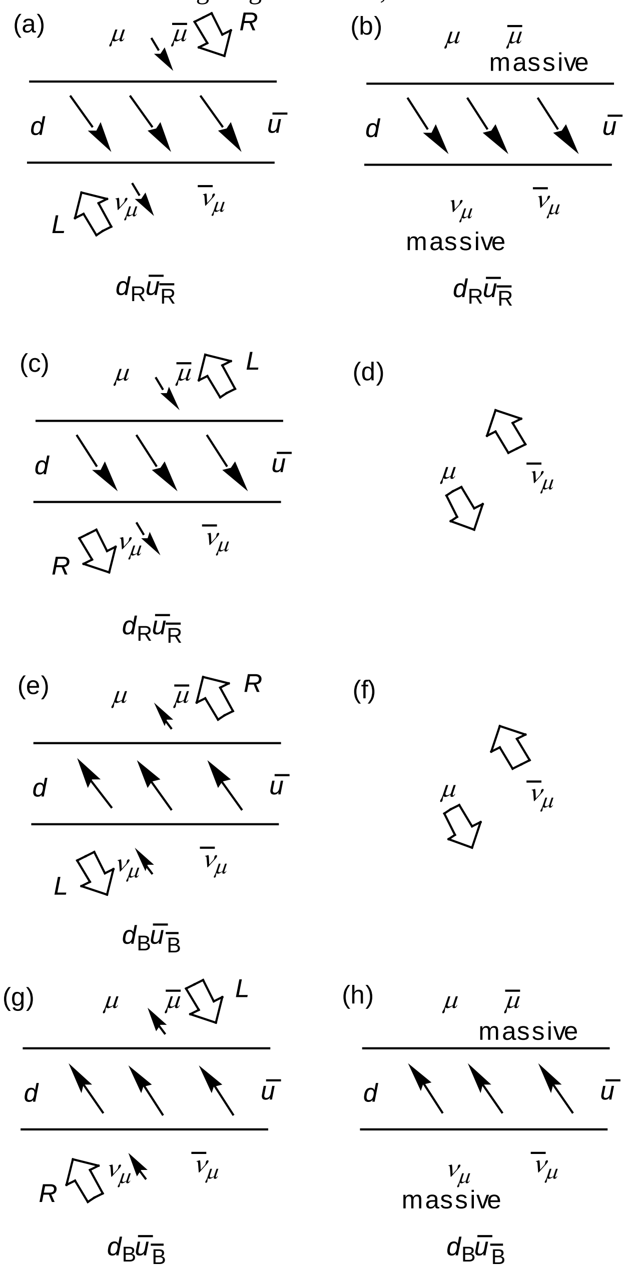

Fig. 8. Decay of minus pion. The small arrows indicate the spin magnetic moment, and the large arrows indicate the direction of the particle moving.

interaction acts on the left-handed helicity element of the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair, such u quark tends to move toward the u quark in a neutron (Fig. 7 (a)). This can be understood as follows. When the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair moves toward the u quark in a neutron, the direction of the spin magnetic moment in the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 7 (a)). Therefore, the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair becomes stable in energy. This is the reason why such u quark tends to move toward the u quark in a neutron. If the u quark in the $u-\bar{u}$ pair moves toward the u quark in a neutron, new $u-u$ bonding can be formed (Fig. 7 (b)). In such a case, u quark in the $u-\bar{u}$ pair can interact with the u quark in a neutron, and $\bar{u}$ antiquark in the $u-\bar{u}$ pair can interact with the d quark in a neutron. Therefore, $u-u$ bonding can be formed in a neutron (proton), and the $\bar{u}-d$ bonding can be formed in a π^- meson (Fig. 7 (b)). In such a case, we can observe that the weak interaction acts on the left-handed helicity elements in u quark.

Let us next look into the case where the weak interaction acts on the right-handed particles and the left-handed antiparticles (Fig. 7 (c), (d)).

If u quark in the $u-\bar{u}$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair, such u quark tends to move toward the d quark in a neutron (Fig. 7 (c)). This can be understood as follows. When the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair moves toward the d quark in a neutron, the direction of the spin magnetic moment in the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 7 (c)). Therefore, the u quark with $q_{\mathrm{W}} = +1/2$ in the $u-\bar{u}$ pair becomes stable in energy. This is the reason why such u quark tends to move toward the d quark in a neutron. In such a case, u quark in the $u-\bar{u}$ pair can interact with the d quark in a neutron, and $\bar{u}$ antiquark in the $u-\bar{u}$ pair can interact with the u quark in a neutron. Therefore, $u-d$ bonding can be formed in a neutron and the $u-\bar{u}$ pair can be formed in a vacuum (Fig. 7 (d)). The last state (Fig. 7 (d)) is exactly the same with the initial state (Fig. 7 (c)). In such a case, we can observe that the weak interaction does not seem to act on the right-handed helicity elements in u quark. On the other hand, such $\bar{u}$ antiquark and u quark become massive as a consequence of these interactions (Fig. 7 (d)).

Therefore, it should be noted that weak interaction can essentially act on the right-handed helicity elements as well as the left-handed helicity elements in the particle. On the other hand, we cannot observe any change when the weak interaction acts on the right-handed helicity elements in the particle. This is the reason why we can observe that parity is violated and the weak interaction only acts on the left-handed helicity elements in a particle and on the right-handed helicity elements in an antiparticle (Fig. 7 (a), (b)). On the other hand, when the weak interaction acts on the right-handed helicity elements in a particle and on the left-handed helicity elements in an antiparticle, such particles and antiparticles become massive as a consequence of these interactions (Fig. 7 (c), (d)).

5.2 $\pi^- \to \mu + \overline{\nu}_\mu$

Let us next consider the decay of π^- meson ($\pi^- \to \mu + \overline{\nu}_\mu$). A free π^- will decay by emitting a W^-, which finally produces a muon (μ) and anti-muon-neutrino ($\overline{\nu}_\mu$) (Fig. 8).

The strong force becomes very strong because of the sharp confinement of the lines of the magnetic forces between two quarks, and thus the $\mu - \overline{\mu}$ and $\nu_\mu - \overline{\nu}_\mu$ pairs production energy is reached before $\overline{u}$ antiquark and d quarks in a π^- meson can be separated (Fig. 8). In such a case, there is strong magnetic field as a consequence of the penetration of the magnetic field originating from the magnetic monopoles of $\overline{u}$ antiquark and d quark into the vacuum within the range of 10^{-18} m from the bond axis of the two $\overline{u}$ antiquark and d quark. This strong magnetic field can be considered as massive W^- boson, which can move within the range of 10^{-18} m from the bonding axis of the two $\overline{u}$ antiquark and d quark. Now, we must consider three cases ($d_R\overline{u}_{\overline{R}}$, $d_B\overline{u}_{\overline{B}}$, and $d_G\overline{u}_{\overline{G}}$) because of the white color (colorless) charge within a π^- meson.

Let us first consider the $d_R\overline{u}_{\overline{R}}$ (Fig. 8 (a)–(d)). In such a case, the strong magnetic fields go from the d quark (N pole) to the $\overline{u}$ antiquark ($\overline{\text{N}}$ (S) pole). It should be noted that there are right-handed helicity elements as well as the left-handed helicity elements in all massive particles, and there are left-handed helicity elements as well as the right-handed helicity elements in all massive antiparticles. On the other hand, it has been considered that the weak interaction acts only on left-handed particles and right-handed antiparticles (Fig. 8 (a), (b)).

Let us first look into the case where the weak interaction acts on the left-handed particles and the right-handed antiparticles.

If ν_μ in the $\nu_\mu - \overline{\nu}_\mu$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the left-handed helicity element of the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair, such ν_μ tends to move toward the d quark in a π^- meson (Fig. 8 (a)). This can be understood as follows. When the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair moves toward the d quark in a π^- meson, the direction of the spin magnetic moment in the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (a)). Therefore, the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes stable in energy. This is the reason why such ν_μ tends to move toward the d quark in a π^- meson (Fig. 8 (a)). If the ν_μ in the $\nu_\mu - \overline{\nu}_\mu$ pair moves toward the d quark in a π^- meson, the ν_μ just goes through the d quark and goes away from a π^- meson. On the other hand, ν_μ becomes massive as a consequence of these interactions (Fig. 8 (b)).

If $\overline{\mu}$ in the $\mu - \overline{\mu}$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair, such $\overline{\mu}$ tends to move toward the $\overline{u}$ antiquark in a π^- meson (Fig. 8 (a)). This can be understood as follows. When the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair moves toward the $\overline{u}$ antiquark in a π^- meson, the direction of the spin magnetic moment in the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (a)). Therefore, the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair becomes stable in energy. This is the reason why such $\overline{\mu}$ tends to move toward the $\overline{u}$ antiquark in a π^- meson. If the $\overline{\mu}$ in the $\mu - \overline{\mu}$ pair moves toward the $\overline{u}$ antiquark in a π^- meson, the $\overline{\mu}$ just goes through the $\overline{u}$ antiquark and goes away from a π^- meson (Fig. 8 (b)). Therefore, we cannot observe weak interaction in this case. On the other hand, $\overline{\mu}$ becomes massive as a consequence of these interactions (Fig. 8 (b)).

Let us next look into the case where the weak interaction acts on the right-handed particles and the left-handed antiparticles (Fig. 8 (c), (d)).

If ν_μ in the $\nu_\mu - \overline{\nu}_\mu$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair, such ν_μ tends to move toward the $\overline{u}$ antiquark in a π^- meson (Fig. 8 (c)). This can be understood as follows. When the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair moves toward the $\overline{u}$ antiquark in a π^- meson, the direction of the spin magnetic moment in the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (c)). Therefore, the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes stable in energy. This is the reason why such ν_μ tends to move toward the $\overline{u}$ antiquark in a π^- meson. In such a case, ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair can contact with the $\overline{u}$ antiquark in a neutron. Therefore, ν_μ and $\overline{u}$ can vanish (Fig. 8 (d)).

If $\overline{\mu}$ in the $\mu - \overline{\mu}$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the left-handed helicity element of the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair, such $\overline{\mu}$ tends to move toward the d quark in a π^- meson (Fig. 8 (c)). This can be understood as follows. When the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair moves toward the d quark in a π^- meson, the direction of the spin magnetic moment in the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (c)). Therefore, the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair becomes stable in energy. This is the reason why such $\overline{\mu}$ tends to move toward the d quark in a π^- meson. In such a case, $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair can contact with the d quark in a π^- meson. Therefore, $\overline{\mu}$ and d can vanish (Fig. 8 (d)).

Therefore, we can observe the weak interactions if the weak interaction acts on the right-handed particles and left-handed antiparticles. On the other hand, the left-handed (right-handed) helicity element is much more dominant than the right-handed (left-handed) helicity element in leptons (anti-leptons). Therefore, we cannot usually observe weak interaction in the case of the $d_R \overline{u}_{\overline{R}}$.

Let us next consider the $d_B \overline{u}_{\overline{B}}$ (Fig. 8 (e)–(h)). In such a case, the strong magnetic fields go from the $\overline{u}$ antiquark ($\overline{S}$ (N) pole) to the d quark (S pole). It should be noted that there are right-handed helicity elements as well as the left-handed helicity elements in all massive particles, and there are left-handed helicity elements as well as the right-handed helicity elements in all massive antiparticles. On the other hand, it has been considered that the weak interaction acts only on left-handed particles and right-handed antiparticles.

Let us first look into the case where the weak interaction acts on the left-handed particles and the right-handed antiparticles (Fig. 8 (e), (f)).

If ν_μ in the $\nu_\mu - \overline{\nu}_\mu$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the left-handed helicity element of the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair, such ν_μ tends to move toward the $\overline{u}$ antiquark in a π^- meson (Fig. 8 (e)). This can be understood as follows. When the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair moves toward the $\overline{u}$ antiquark in a π^- meson, the direction of the spin magnetic moment in the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (e)). Therefore, the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes stable in energy. This is the reason why such ν_μ tends to move toward the $\overline{u}$ antiquark in a π^- meson. In such a case, ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair can contact with the $\overline{u}$ quark in a π^- meson. Therefore, ν_μ and $\overline{u}$ can vanish (Fig. 8 (f)).

If $\overline{\mu}$ in the $\mu - \overline{\mu}$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair, such $\overline{\mu}$ tends to move toward the d quark in a π^- meson (Fig. 8 (e)). This can be understood as follows. When the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair moves toward the d quark in a π^- meson, the direction of the spin magnetic moment in the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (e)). Therefore, the $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair becomes stable in energy. This is the reason why such $\overline{\mu}$ tends to move toward the d quark in a π^- meson. In such a case, $\overline{\mu}$ with $q_W = +1/2$ in the $\mu - \overline{\mu}$ pair can contact with the d quark in a π^- meson. Therefore, $\overline{\mu}$ and d can vanish (Fig. 8 (f)).

The left-handed (right-handed) helicity element is much more dominant than the right-handed (left-handed) helicity element in leptons (anti-leptons). Therefore, we can observe weak interaction in the case of the $d_B \overline{u}_{\overline{B}}$.

Let us next look into the case where the weak interaction acts on the right-handed particles and the left-handed antiparticles (Fig. 8 (g), (h)).

If ν_μ in the $\nu_\mu - \overline{\nu}_\mu$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair, such ν_μ tends to move toward the d quark in a π^- meson (Fig. 8 (g)). This can be understood as follows. When the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair moves toward the d quark in a π^- meson, the direction of the spin magnetic moment in the ν_μ with $q_W = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (g)). Therefore, the ν_μ with

$q_{\mathrm{W}} = +1/2$ in the $\nu_\mu - \overline{\nu}_\mu$ pair becomes stable in energy. This is the reason why such ν_μ tends to move toward the d quark in a π^- meson. If the ν_μ in the $\nu_\mu - \overline{\nu}_\mu$ pair moves toward the d quark in a π^- meson, the ν_μ just goes through the d quark and goes away from a π^- meson (Fig. 8 (h)). On the other hand, ν_μ becomes massive as a consequence of these interactions (Fig. 8 (h)).

If $\overline{\mu}$ in the $\mu - \overline{\mu}$ pair comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the left-handed helicity element of the $\overline{\mu}$ with $q_{\mathrm{W}} = +1/2$ in the $\mu - \overline{\mu}$ pair, such $\overline{\mu}$ tends to move toward the $\overline{u}$ antiquark in a π^- meson (Fig. 8 (g)). This can be understood as follows. When the $\overline{\mu}$ with $q_{\mathrm{W}} = +1/2$ in the $\mu - \overline{\mu}$ pair moves toward the $\overline{u}$ antiquark in a π^- meson, the direction of the spin magnetic moment in the $\overline{\mu}$ with $q_{\mathrm{W}} = +1/2$ in the $\mu - \overline{\mu}$ pair becomes the same with that of the magnetic fields of the weak bosons (Fig. 8 (g)). Therefore, the $\overline{\mu}$ with $q_{\mathrm{W}} = +1/2$ in the $\mu - \overline{\mu}$ pair becomes stable in energy. This is the reason why such $\overline{\mu}$ tends to move toward the $\overline{u}$ antiquark in a π^- meson. If the $\overline{\mu}$ in the $\mu - \overline{\mu}$ pair moves toward the $\overline{u}$ antiquark in a π^- meson, the $\overline{\mu}$ just goes through the $\overline{u}$ antiquark and goes away from a π^- meson. Therefore, we cannot observe weak interaction in this case (Fig. 8 (h)). On the other hand, $\overline{\mu}$ becomes massive as a consequence of these interactions.

Therefore, we can observe the weak interactions if the weak interaction acts on the left-handed particles and right-handed particles. Most of the leptons are left-handed, and most of the anti-leptons are right-handed. Therefore, we can observe weak interaction in the case of the $d_{\mathrm{B}}\overline{u}_{\overline{\mathrm{B}}}$.

Therefore, it should be noted that weak interaction can essentially act on the right- (left-) handed helicity elements as well as the left- (right-) handed helicity elements in the particle (antiparticle). The left-handed (right-handed) helicity element is much more dominant than the right-handed (left-handed) helicity element in leptons (anti-leptons). This is the reason why we can observe that parity is violated and the weak interaction only acts on the left-handed helicity elements in a particle and on the right-handed helicity elements in an antiparticle.

5.3 $\mu + \overline{\nu}_\mu \rightarrow e + \overline{\nu}_e$

Let us next consider the case where the μ and $\overline{\nu}_\mu$ are converted to the e and $\overline{\nu}_e$ ($\mu + \overline{\nu}_\mu \rightarrow e + \overline{\nu}_e$) (Fig. 9). Since the left-handed (right-handed) helicity element is much more dominant than the right-handed (left-handed) helicity element in leptons (anti-leptons), we consider only the left-handed (right-handed) helicity element in leptons (anti-leptons) in this section.

Let us first consider the case where the μ and $\overline{\nu}_\mu$ go into the $u - \overline{u}$ pair in vacuum (Fig. 9 (a)–(d)). The strong force becomes very strong because of the sharp confinement of the lines of the magnetic forces between u and $\overline{u}$, and thus the $e - \overline{e}$ pair and the $\nu_e - \overline{\nu}_e$ pair production energy is reached before $u - \overline{u}$ pair in vacuum can be separated (Fig. 9). The kinds of the particle–antiparticle pairs produced from the vacuum depend on the energy in this environment. In such a case, there is strong magnetic field as a consequence of the magnetic field originating from the magnetic monopoles of u and $\overline{u}$ into the vacuum within the range of 10^{-18} m from the bond axis of the two u quark and $\overline{u}$ antiquark. This strong magnetic field can be considered as massive W^- boson, which can move within the range of 10^{-18} m from the bonding axis of the two u quark and $\overline{u}$ antiquark. In such a case, the strong magnetic fields go from the u quark (N pole) to the $\overline{u}$ antiquark (S pole). It should be noted that there are right-handed helicity elements as well as the left-handed helicity elements in all massive particles, and there are left-handed helicity elements as well as the right-handed helicity elements in all massive antiparticles. On the other hand, it has been considered that the weak interaction acts only on the left-handed particles and the right-handed antiparticles.

If μ comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the left-handed helicity element of the μ with $q_{\mathrm{W}} = -1/2$, such μ tends to move toward the $\overline{u}$ antiquark in a $u - \overline{u}$ pair (Fig. 9 (a)). This can be understood as follows. When the μ with $q_{\mathrm{W}} = -1/2$ moves toward the $\overline{u}$ antiquark in a $u - \overline{u}$ pair, the direction of the spin magnetic moment in the μ with $q_{\mathrm{W}} = -1/2$ becomes the same with that of the magnetic fields of the weak bosons (Fig. 9 (a)). Therefore, the μ with $q_{\mathrm{W}} = -1/2$ becomes stable in energy. This is the reason why such μ tends to move toward the $\overline{u}$ antiquark in a $u - \overline{u}$ pair. In such a case, μ with $q_{\mathrm{W}} = -1/2$ can contact with the $\overline{u}$ antiquark in $u - \overline{u}$ pair. Therefore, μ and $\overline{u}$ can vanish (Fig. 9 (b)).

If $\overline{\nu}_\mu$ comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the $\overline{\nu}_\mu$ with $q_{\mathrm{W}} = -1/2$, such $\overline{\nu}_\mu$ tends to move toward the u quark in a $u - \overline{u}$ pair. This can be understood as follows. When the $\overline{\nu}_\mu$ with $q_{\mathrm{W}} = -1/2$ moves toward the u quark in a $u - \overline{u}$

pair, the direction of the spin magnetic moment in the $\overline{\nu}_\mu$ with $q_{\mathrm{W}} = -1/2$ becomes the same with that of the magnetic fields of the weak bosons (Fig. 9 (a)). Therefore, the $\overline{\nu}_\mu$ with $q_{\mathrm{W}} = -1/2$ becomes stable in energy. This is the reason why such $\overline{\nu}_\mu$ tends to move toward the u quark in a $u-\overline{u}$ pair. In such a case, $\overline{\nu}_\mu$ with $q_{\mathrm{W}} = -1/2$ can contact with the u quark in $u-\overline{u}$ pair. Therefore, $\overline{\nu}_\mu$ and u can vanish (Fig. 9 (b)).

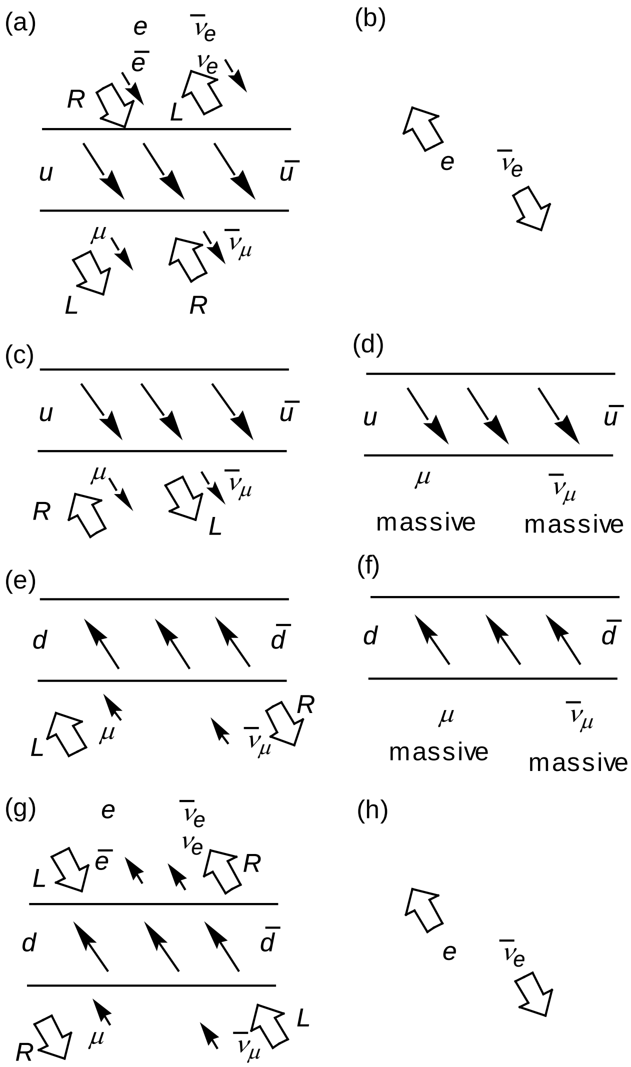

Fig. 9. Converting of the leptons and anti-leptons from the generation 2 to the generation 1. The small arrows indicate the spin magnetic moment, and the large arrows indicate the direction of the particle moving.

If $\overline{e}$ comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the $\overline{e}$ with $q_{\mathrm{W}} = +1/2$, such $\overline{e}$ tends to move toward the $\overline{u}$ antiquark in a $u-\overline{u}$ pair in vacuum. This can be understood as follows. When the $\overline{e}$ with $q_{\mathrm{W}} = +1/2$ moves toward the $\overline{u}$ antiquark in a $u-\overline{u}$ pair, the direction of the spin magnetic moment in the $\overline{e}$ with $q_{\mathrm{W}} = +1/2$ becomes the same with that of the magnetic fields of the weak bosons (Fig. 9 (a)). Therefore, the $\overline{e}$ with $q_{\mathrm{W}} = +1/2$ becomes stable in energy. This is the reason why such $\overline{e}$ tends to move toward the $\overline{u}$ antiquark in a $u-\overline{u}$ pair.

If ν_e comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the left-handed helicity element of the ν_e with $q_{\mathrm{W}} = +1/2$, such ν_e tends to move toward the u quark in a $u-\overline{u}$ pair. This can be understood as follows. When the ν_e with $q_{\mathrm{W}} = +1/2$ moves toward the u quark in a $u-\overline{u}$ pair, the direction of the spin magnetic moment in the ν_e with $q_{\mathrm{W}} = +1/2$ becomes the same with that of the magnetic fields of the weak bosons (Fig. 9 (a)). Therefore, the ν_e with $q_{\mathrm{W}} = +1/2$ becomes stable in energy. This is the reason why such ν_e tends to move toward the u quark in a $u-\overline{u}$ pair.

If the $\overline{e}$ antiparticle in $e-\overline{e}$ pair and ν_e particle in $\nu_e-\overline{\nu}_e$ pair move toward each other, the $\overline{e}$ antiparticle can finally contact with the ν_e particle (Fig. 9 (a)). In such a case, these $\overline{e}$ antiparticle and ν_e particle vanish. Therefore, the e particle and the $\overline{\nu}_e$ antiparticle emerge from vacuum (Fig. 9 (b)). Therefore, finally, we can observe the weak interaction that the μ and $\overline{\nu}_\mu$ (generation 2) are converted to the e and $\overline{\nu}_e$ (generation 1) (Fig. 9 (a), (b)). In these cases, the weak interaction acts on the right-handed helicity elements in $\overline{\nu}_\mu$ antiparticle and on the left-handed helicity elements in e particle. Since the left-handed (right-handed) helicity element is much more dominant than the right-handed (left-handed) helicity element in e particle ($\overline{\nu}_\mu$ antiparticle), such vanishing of particle–antiparticle pairs can usually be observed.

Let us next consider the case where the μ and $\overline{\nu}_\mu$ go into the $d-\overline{d}$ pair in vacuum (Fig. 9 (e)–(h)).

If μ comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the left-handed helicity element of the μ with $q_{\mathrm{W}} = -1/2$, such μ tends to move toward the d quark in a $d-\overline{d}$ pair. This can be understood as follows. When the μ with $q_{\mathrm{W}} = -1/2$ moves toward the d quark in a $d-\overline{d}$ pair, the direction of the spin magnetic moment in the μ with $q_{\mathrm{W}} = -1/2$ becomes the same with that of the magnetic fields of the weak bosons (Fig. 9 (e)). Therefore, the μ with $q_{\mathrm{W}} = -1/2$ becomes stable in energy. This is the reason why such μ tends to move toward the d quark in a $d-\bar{d}$ pair (Fig. 9 (e)). Therefore, the μ just goes through the d quark and goes away from a $d-\bar{d}$ pair. Therefore, we cannot observe weak interaction in this case. On the other hand, μ becomes massive as a consequence of these interactions (Fig. 9 (f)).

If $\bar{\nu}_\mu$ comes into the small region and feels the strong magnetic fields, and the weak interaction acts on the right-handed helicity element of the $\bar{\nu}_\mu$ with $q_W = -1/2$, such $\bar{\nu}_\mu$ tends to move toward the $\bar{d}$ antiquark in a $d-\bar{d}$ pair (Fig. 9 (e)). This can be understood as follows. When the $\bar{\nu}_\mu$ with $q_W = -1/2$ moves toward the $\bar{d}$ antiquark in a $d-\bar{d}$ pair, the direction of the spin magnetic moment in the $\bar{\nu}_\mu$ with $q_W = -1/2$ becomes the same with that of the magnetic fields of the weak bosons (Fig. 9 (e)). Therefore, the $\bar{\nu}_\mu$ with $q_W = -1/2$ becomes stable in energy. This is the reason why such $\bar{\nu}_\mu$ tends to move toward the $\bar{d}$ antiquark in a $d-\bar{d}$ pair. Therefore, the $\bar{\nu}_\mu$ just goes through the $\bar{d}$ antiquark and goes away from a $d-\bar{d}$ pair. Therefore, we cannot observe weak interaction in this case. On the other hand, $\bar{\nu}_\mu$ becomes massive as a consequence of these interactions (Fig. 9 (f)).

5.4 Parity Violation of ^{60}Co

In the 1950s, Yang and Lee suggested that the weak interaction might violate parity. Wu and collaborators in 1957 discovered that the weak interaction violates parity. The experimental results showed that the number of electrons moving toward the opposite direction of the spin magnetic moments is much larger than that moving toward the same direction of the spin magnetic moment in ^{60}Co (Fig. 10). This can be understood as follows. We can see from Fig. 10 (a) that most of $\bar{e}$ moves toward $\bar{u}$ antiquark, and thus $\bar{e}$ moves toward the same direction of the spin magnetic moment of the $u-\bar{u}$ pair, that is, of the ^{60}Co. Since e moves toward the opposite direction of $\bar{e}$ moving, e moves toward the opposite direction of the spin magnetic moment of the $u-\bar{u}$ pair, that is, of the ^{60}Co (Fig. 10 (a)). This is the reason why the number of electrons moving toward the opposite direction (Fig. 10 (a)) of the spin magnetic moments is much larger than that moving toward the same direction (Fig. 10 (b)) of the spin magnetic moment in ^{60}Co. On the other hand, it should be noted that the number of the electrons moving toward the same direction of the spin magnetic moment (Fig. 10 (b)) in ^{60}Co is very small, but not exactly zero. This can be understood as follows. Electron and electron-neutrino are massive, and thus the right-handed helicity element is not zero even though the light-handed helicity elements are much more dominant than the right-handed helicity element in electron and electron-neutrino. Small part of $\bar{e}$ moves toward u quark, and thus $\bar{e}$ moves toward the opposite direction of the spin magnetic moment of the $u-\bar{u}$ pair, that is, of ^{60}Co (Fig. 10 (b)). Since e moves toward the opposite direction of $\bar{e}$ moving, e moves toward the same direction of the spin magnetic moment of the $u-\bar{u}$ pair, that is, of ^{60}Co (Fig. 10 (b)). This is the reason why the number of the electrons moving

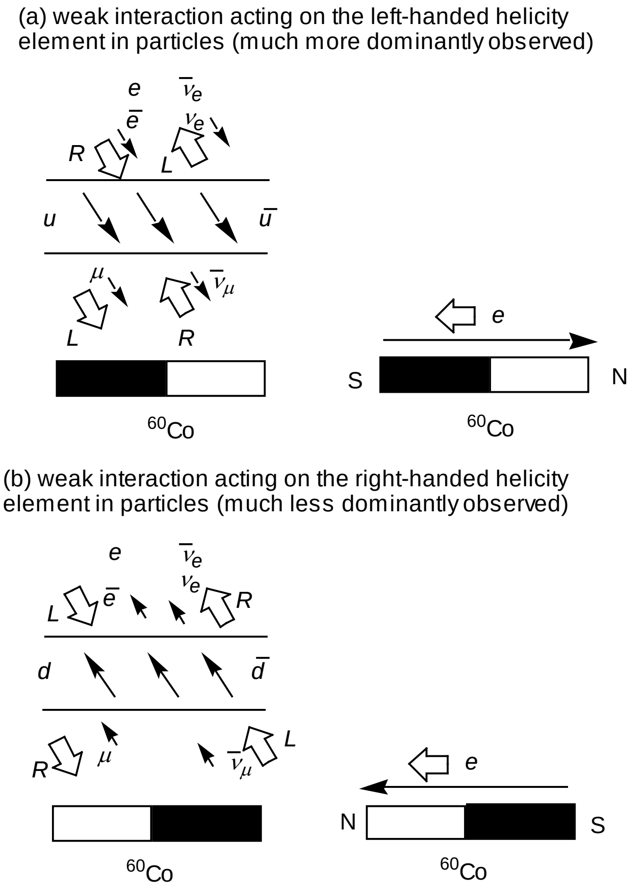

Fig. 10. Relationships between the direction of the electron moving and the spin magnetic moment in ^{60}Co. The small arrows indicate the spin magnetic moment, and the large arrows indicate the direction of the particle moving.

toward the same direction of the spin magnetic moment in ^{60}Co is very small, but not exactly zero.

It has been considered that the weak interaction only acts on the left-handed particles and right-handed antiparticles (parity violation). However, according to our theory, weak interaction is not directly related to such parity violation. That is, according to our theory, weak interaction acts on the right- (left-) handed particles (antiparticles) as well as on the left- (right-) handed particles (antiparticles). That is, weak forces themselves do not violate the parity. Therefore, the parity violation is not essential in weak interaction. On the other hand, the left- (right-) handed helicity elements are much more dominant than the right- (left-) handed helicity elements in leptons (anti-leptons). Therefore, we observe that the weak interaction seems to act only on the left- (right-) handed particles (antiparticles). That is, dominance in the left- (right-) handed helicity elements in leptons (anti-leptons) is the main reason why we observe parity violation even though the weak forces are not directly related to the parity violation.

6. Relationships between the Chemical Interactions and Weak Interactions

It has been considered that weak interactions are quite different from other interactions. On the other hand, according to our theory, weak interactions are very similar to chemical reactions. In chemical reaction, atomic bonding and types of molecules can be changed via the electron exchange. On the other hand, in weak interactions, the bonding between the quarks and antiquarks and types of the leptons and anti-leptons can be changed via the weak boson exchange. Only the difference is that the product materials (A–D and B–C) can be formed by the elements of the reactants (A–B and C–D (i.e., A, B, C, and D)) in chemical reactions (Fig. 11 (a)), while the final product states (u, u, e and $\overline{\nu}_e$) can be formed by the particle–antiparticles pairs ($u-\overline{u}$, $\mu-\overline{\mu}$, $\nu_\mu-\overline{\nu}_\mu$, $e-\overline{e}$, and $\nu_e-\overline{\nu}_e$) in vacuum as well as the elements of the reactants (u and d) (Fig. 11 (b)). The kinds of the particle–antiparticle pairs generated from the vacuum depends on the energy states of the environment in vacuum. Furthermore, the area (10^{-10} [m]) under which chemical reaction occurs is much larger than that (10^{-18} [m]) under which weak interaction occurs. Furthermore, the produced energies for chemical reaction is much smaller than that for weak interaction (Fig. 11).

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. 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, by the cancellation of the intrinsic extremely large right- and left-handed chirality elements in spin magnetic moments. On the other hand, if weak interaction occurs, the rest energy difference, related to the difference of the masses between the reactant and product, can be produced. This energy as a consequence of the weak interaction originates from the fact that the cancellation of the intrinsic extremely large right- and left-handed chirality elements in spin magnetic moments is broken by the driving force of the magnetic monopoles. Therefore, the difference of the degree of the cancellation of the intrinsic extremely large right- and left-handed chirality elements in spin magnetic moments between the reactants and products is the origin of the rest energy difference ($\Delta mc^2\left(=\Delta q_g c^2\right)$) as a consequence of the weak interactions.

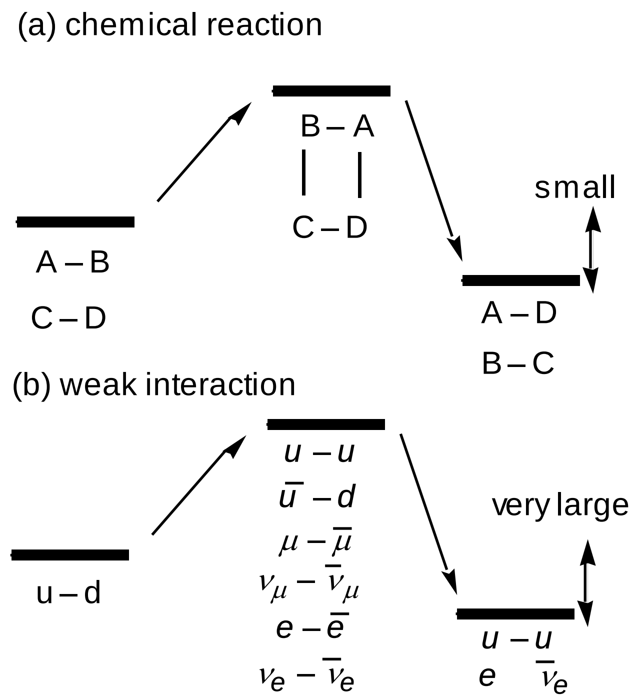

Fig. 11. Comparison of the chemical reaction with the weak interaction.

7. Relationships between the Meissner Effects in Superconductivity and Weak Interactions in Higgs Mechanism

In superconductivity, the Cooper pairs can be formed. The Cooper pairs can move according to the external magnetic fields applied to superconducting specimen. The circulated magnetic field can be induced by such moving of Cooper pairs, according to the Ampère's law. The external applied magnetic fields are expelled from the superconducting specimen by such circulated magnetic fields. This phenomenon is Meissner effect (Fig. 12 (a), Table 1).

Let us next look into this phenomenon in view of the Higgs mechanism. In superconductivity, it has been considered that the fluctuation of the Cooper pairs is the origin of the induced magnetic fields, according to the Ampère's law, by which the magnetic field (magnetic photon) becomes massive in superconductivity. We can

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consider that the fluctuation of the Cooper pairs can induce the circulated magnetic fields. The circulated magnetic fields (massless magnetic photon) is related to the massless Nambu–Goldstone particle (Higgs boson (H_{NG})) (Fig. 12 (a)). The external applied magnetic fields are expelled from the superconducting specimen by such circulated magnetic fields. The external applied magnetic field is related to the massless gauge boson (magnetic photon γ_{m}) (Fig. 12 (a)). That is, the massless Nambu–Goldstone particle H_{NG} is absorbed by the

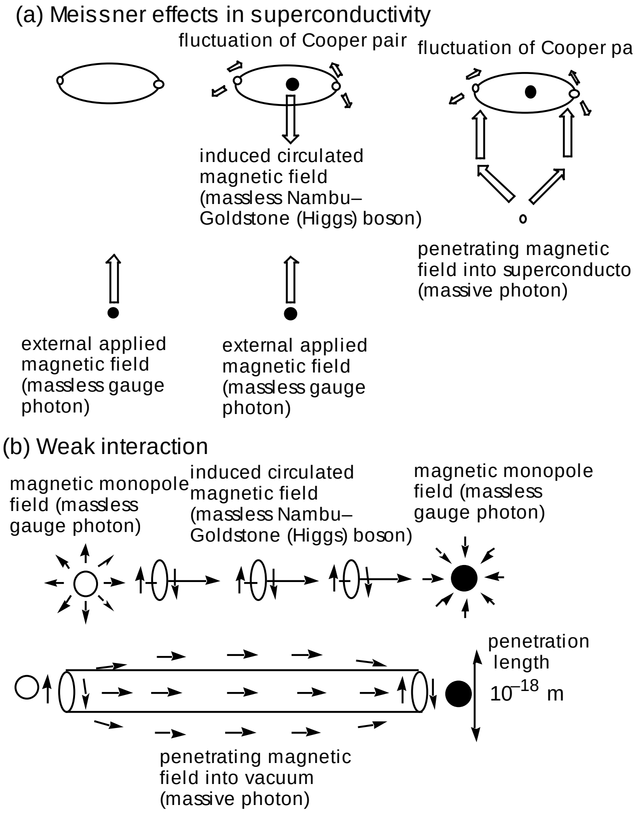

Fig. 12. Higgs mechanism in superconductivity and weak interaction.

massless gauge boson γ_{m}. Therefore, the penetrating of the external applied magnetic fields is suppressed, and thus the external applied magnetic field can penetrate into the superconducting specimen only within the penetration lengths of the magnetic field. That is, the massless gauge boson γ_{m} becomes finally massive, and such massive gauge boson can enter into the superconducting specimen only within the penetration depth (Fig. 12 (a)). This is the explanation of the Meissner effect in view of the Higgs mechanism.

Let us next compare the Meissner effects in superconductivity with the weak interactions in our theory. The weak isospin charges are the magnetic charges (the magnetic monopole at time axis (Eqs. (25), (26), (31), (32)) and the spin magnetic moment at space axis (Eqs. (7), (14))). The magnetic field originating from the magnetic monopole (color charge) are confined within the one-dimensional by the induced spin magnetic field originating from the moving electric charge (Ampère's law), as shown in Fig. 12 (b). On the other hand, such confinement is not perfect and thus the magnetic fields slightly (10^{-18} [m]) penetrate into vacuum from the bond axis between two neighboring quarks and antiquarks, as shown in Fig. 12 (b). This is very similar to the

Table 1. Higgs mechanism in the superconductivity and weak interactions.

	superconductivity	weak interactions
gauge boson	external applied magnetic fields	magnetic monopoles from quarks and antiquarks
Nambu–Goldstone (Higgs) boson	induced magnetic fields as a consequence of the Ampère's law	induced circulated magnetic fields as a consequence of the Ampère's law
origin of the Nambu–Goldstone (Higgs) boson	fluctuation of the Cooper pairs (electrical current of the Cooper pairs)	fluctuation of the vibration of the quarks and antiquarks
massive boson	external applied magnetic fields mostly canceled by the induced magnetic fields as a consequence of the Ampère's law	magnetic monopoles from quarks and antiquarks synthesized by the induced circulated magnetic fields as a consequence of the Ampère's law

penetration of the magnetic fields in superconductor in the Meissner effects. In superconductivity, it has been considered that the fluctuation of the Cooper pairs is the origin of the induced circulated magnetic fields (the Higgs mechanism), according to the Ampère's law, by which the magnetic field (magnetic photon) becomes massive in superconductivity. In a similar way, fluctuation of the vibration of the quark and antiquarks in hadron and vacuum is the origin of the induced circulated magnetic field (the massless Nambu–Goldstone particles (Higgs bosons (H^{+}, H^{-}, and H^{0})), according to the Ampère's law, by which the magnetic fields (the massless gauge weak bosons (γ_{c} and γ_{m})) become massive in vacuum. The massless Nambu–Goldstone particles (Higgs bosons) (the circulated magnetic field induced according to the Ampère's law) originating from the fluctuation of the vibrations of the quarks and antiquarks in hadrons and vacuum, are absorbed by the massless gauge bosons (the magnetic fields originating from the magnetic monopoles in quarks and antiquarks in hadrons and vacuum) (Fig. 12 (b)). Therefore, such massless gauge boson absorbing the Nambu–Goldstone bosons becomes massive. The finally massive bosons are related to the massive weak bosons which are composed from the circulated magnetic field induced according to the Ampère's law and the magnetic fields originating from the magnetic monopoles in quarks and antiquarks in hadrons and vacuum. Therefore, the weak bosons are massive fields of the superposition of the magnetic monopole (γ_{c}) and the induced spin magnetic moment (γ_{m}) originating from the Ampère's law in quarks and antiquarks in hadron and vacuum, within 10^{-18} $[\mathrm{m}]$ from the bonding axis of the neighboring two quarks and antiquarks (Fig. 12 (b)). The weak forces can be generated because massive magnetic photons called massive weak bosons, which are emitted from quarks and antiquarks, and absorbed by quarks, antiquarks, leptons, and anti-leptons (the spin magnetic moment and the magnetic monopoles), are exchanged between quarks, antiquarks, leptons, and anti-leptons.

In summary, the weak bosons γ_{w} such as W^{+}, W^{-}, and Z^{0} are the magnetic field as a consequence of superposition of the magnetic fields originating from the massive gluon (γ_{g}) and the induced circulated spin magnetic fields (γ_{m}).

When particles and antiparticles come into the hadrons and particle–antiparticle pairs in vacuum, such particles and antiparticles can be converted to the another particles and antiparticles, or can become massive via the exchange of the weak bosons (including Higgs bosons), by which the Higgs bosons have been absorbed.

8. Relationships between the Gauge Bosons in the Electric, Magnetic, and Strong, and Weak Forces

According to our research, it is natural to consider that the γ_{w} 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 weak 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 weak bosons are kinds of photons, there is a possibility that the weak boson is closely related to the photons (Fig. 13).

We can consider that the gauge photonic particle medium (γ) for electric forces (γ_{e}), for magnetic forces (γ_{m}), for strong force (γ_{c}), and for weak force (γ_{w}), 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}, the photon γ, which plays a role in the strong force, is observed as the medium of the color field (gluon) γ_{c}, and

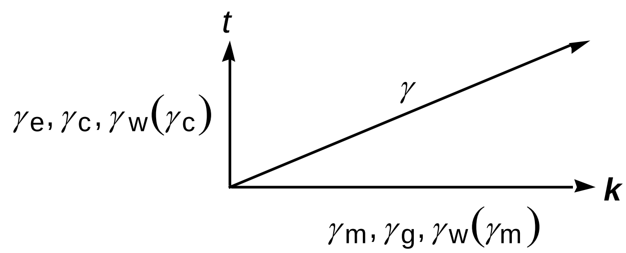

Fig. 13. Relationships between the gauge bosons for the electromagnetic, magnetic, gravitational, electric, strong, and weak forces at the space and time axes.

the photon γ, which plays a role in the weak force, is observed as the medium of the weak field (weak bosons) γ_{w} (Fig. 13).

We do not completely know whether the substance of the weak 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 weak force is generated by the right- and left-handed helicity elements of the magnetic angular momentum, and furthermore, by the magnetic monopole.

9. Concluding Remarks

In this research, we discussed the origin of the weak forces, by comparing the weak force with the gravitational, electric, magnetic, strong, and electromagnetic forces. We also discussed the essential properties of the weak bosons and weak isospin charges. Furthermore, we also discussed the reason why the parity violation can be observed in the weak interactions.

We discussed the weak isospin charges. The weak isospin charges are the magnetic charges (the magnetic monopole at time axis and the spin magnetic moment at space axis).

We also discussed the weak bosons. The confinement of the strong forces is not perfect. Therefore, the weak bosons are magnetic fields of the superposition of the magnetic monopole and the induced spin magnetic moment originating from the Ampère's law in quarks and antiquarks in hadron and vacuum, within the 10^{-18} m from the bonding axis of the neighboring two quarks and antiquarks. The weak forces can be generated because the photons (magnetic fields) called weak bosons, which are emitted from quarks and antiquarks and absorbed by quarks, antiquarks, leptons, and anti-leptons (the spin magnetic moment and the magnetic monopoles), are exchanged between quarks, antiquarks, leptons, and anti-leptons.

The reason why the parity violation can be observed in the weak interactions is also discussed. It has been considered that the weak interaction acts only on the left-handed particles and on the right-handed antiparticles. On the other hand, the reason why the weak interaction acts only on the left-handed particles and on the right-handed antiparticles has not been elucidated. We showed that the right-handed helicity elements as well as the left-handed helicity elements absorb the weak boson. However, we cannot usually observe weak interactions when weak interaction acts on the right-handed particles and the left-handed antiparticles. We elucidated the reason why we usually observe the parity violation as a consequence of the weak force.

The weak interaction ($d \to u + \pi^-$) can essentially act on the right-handed helicity elements as well as the left-handed helicity elements in the particle. On the other hand, we cannot observe any change when the weak interaction acts on the right-handed helicity elements in the particle. This is the reason why we can observe that parity is violated and the weak interaction only acts on the left-handed helicity elements in a particle and on the right-handed helicity elements in an antiparticle. On the other hand, when the weak interaction acts on the right-handed helicity elements in a particle and on the left-handed helicity elements in an antiparticle, such particles and antiparticles become massive as a consequence of these interactions.

The weak interaction ($\pi^- \to \mu + \overline{\nu}_\mu$ and $\mu + \overline{\nu}_\mu \to e + \overline{\nu}_e$) can essentially act on the right- (left-) handed helicity elements as well as the left- (right-) handed helicity elements in the particle (antiparticle). On the other hand, the left-handed (right-handed) helicity element is much more dominant than the right-handed (left-handed) helicity element in leptons (anti-leptons). This is the reason why we can observe that parity is violated and the weak interaction only acts on the left-handed helicity elements in a particle and on the right-handed helicity elements in an antiparticle.

Our theory can also reasonably explain the parity violation of ^{60}Co. It has been considered that the weak interaction only acts on the left-handed particles and right-handed antiparticles (parity violation). However, according to our theory, weak interaction is not directly related to such parity violation. That is, according to our theory, weak interaction acts on the right- (left-) handed particles (antiparticles) as well as on the left- (right-) handed particles (antiparticles). That is, weak forces themselves do not violate the parity. Therefore, the parity violation is not essential in weak interaction. On the other hand, the left- (right-) handed helicity elements are much more dominant than the right- (left-) handed helicity elements in leptons (anti-leptons). Therefore, we observe that the weak interaction seems to act only on the left- (right-) handed particles (antiparticles). That is, dominance in the left- (right-) handed helicity elements in leptons (anti-leptons) is the main reason why we observe parity violation even though the weak forces are not directly related to the parity violation.

It has been considered that weak interactions are quite different from other interactions. On the other hand, according to our theory, weak interactions are very similar to chemical reactions. In chemical reaction, atomic bonding and types of molecules can be changed via the electron exchange. On the other hand, in weak interactions, the bonding between the quarks and antiquarks and types of the leptons and anti-leptons can be changed via the weak boson exchange. Only the difference is that the product materials can be formed by the elements of the reactants in chemical reactions, while the final product states can be formed by the particle–antiparticles pairs in vacuum as well as the elements of the reactants. The kinds of the particle–antiparticle pairs generated from the vacuum depends on the energy states of the environment in vacuum.

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, by the cancellation of the intrinsic extremely large right- and left-handed chirality elements in spin magnetic moments. On the other hand, if weak interaction occurs, the rest energy difference, related to the difference of the masses between the reactant and product, can be produced. This energy as a consequence of the weak interaction originates from the fact that the cancellation of the intrinsic extremely large right- and left-handed chirality elements in spin magnetic moments is broken by the driving force of the magnetic monopoles. Therefore, the difference of the degree of the cancellation of the intrinsic extremely large right- and left-handed chirality elements in spin magnetic moments between the reactants and products is the origin of the rest energy difference ($\Delta mc^2\left(= \Delta q_g c^2\right)$) as a consequence of the weak interactions.

We compared the Meissner effects in superconductivity with the weak interactions in our theory. The weak isospin charges are the magnetic charges (the magnetic monopole at time axis and the spin magnetic moment at space axis). The magnetic field originating from the magnetic monopole (color charge) are confined within the one-dimensional by the induced spin magnetic field originating from the moving electric charge (Ampère's law). On the other hand, such confinement is not perfect and thus the magnetic fields slightly (10^{-18} [m]) penetrate into vacuum from the bond axis between two neighboring quarks and antiquarks. This is very similar to the penetration of the magnetic fields in superconductor in the Meissner effects. In superconductivity, it has been considered that the fluctuation of the Cooper pairs is the origin of the induced circulated magnetic fields (the Higgs mechanism), according to the Ampère's law, by which the magnetic field (magnetic photon) becomes massive in superconductivity. In a similar way, fluctuation of the vibration of the quark and antiquarks in hadron and vacuum is the origin of the induced circulated magnetic field (the massless Nambu–Goldstone particles (Higgs bosons (H^+, H^-, and H^0)), according to the Ampère's law, by which the magnetic fields (the massless gauge weak bosons (γ_c and γ_m)) become massive in vacuum. The massless Nambu–Goldstone particles (Higgs bosons) (the circulated magnetic field induced according to the Ampère's law) originating from the fluctuation of the vibrations of the quarks and antiquarks in hadrons and vacuum, are absorbed by the massless gauge bosons (the magnetic fields originating from the magnetic monopoles in quarks and antiquarks in hadrons and vacuum). Therefore, such massless gauge boson absorbing the Nambu–Goldstone bosons becomes massive. The finally massive bosons are related to the massive weak bosons which are composed from the circulated magnetic field induced according to the Ampère's law and the magnetic fields originating from the magnetic monopoles in quarks and antiquarks in hadrons and vacuum. Therefore, the weak bosons are massive fields of the superposition of the magnetic monopole (γ_c) and the induced spin magnetic moment (γ_m) originating from the Ampère's law in quarks and antiquarks in hadron and vacuum, within 10^{-18} [m] from the bonding axis of the neighboring two quarks and antiquarks. The weak forces can be generated because massive magnetic photons called massive weak bosons, which are emitted from quarks and antiquarks, and absorbed by quarks, antiquarks, leptons, and anti-leptons (the spin magnetic moment and the magnetic monopoles), are exchanged between quarks, antiquarks, leptons, and anti-leptons.

Acknowledgments

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