Theory of Colorless and Electrically Neutral Quarks: Neutrino-like Quarks

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The theory of colored and electrically charged gauge bosons introduced by the author postulates the existence of colorless and electrically neutral quarks which play the same role in decay processes as neutrinos. We discuss here about the colorless and electrically neutral quarks.

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I. INTRODUCTION

In a recent paper [1], the author builds up a theory of colored and electrically charged gauge bosons mediating baryon number and lepton number conserving interactions, which introduces six colorless and electrically neutral quarks, which we shall call *cen-quarks*,

$$\kappa_u,\ \kappa_c,\ \kappa_t,\ \kappa_d,\ \kappa_s,\ \kappa_b. \tag{1}$$

We discuss here about the colorless and electrically neutral quarks briefly.

II. COLORLESS AND ELECTRICALLY NEUTRAL QUARKS

Our theory [1] deals with the transitions in which the two states of a quark q, the colored and electrically charged state $q_i^{Q/e}$ and the colorless and electrically neutral state κ_q, can transform into each other through the emission or absorption of a colored and electrically charged gauge boson $W_i^{Q/e}$:

$$q_i^{Q/e} \rightleftarrows \kappa_q + W_i^{Q/e}, \tag{2}$$

where $i = r, g, b$, $Q/e = +\frac{2}{3}$ for $q = u, c, t$, and $Q/e = -\frac{1}{3}$ for $q = d, s, b$.

Cen-quarks are colorless and electrically neutral quarks, whereas neutrinos are colorless and electrically neutral leptons. The properties and characteristics of cen-quarks are as follows:

1. They have spin $\frac{1}{2}$ and baryon number $\frac{1}{3}$.

2. The left-handed cen-quarks have isospin $\frac{1}{2}$: The isospin charge T_3 and hypercharge Y of each left-handed cen-quark are from $\frac{Q}{e} = T_3 + \frac{1}{2}Y$

$$T_3|\kappa_q, L\rangle = \begin{cases} -\frac{1}{2}|\kappa_q, L\rangle \ \text{ for } \ q = u, c, t, \\ +\frac{1}{2}|\kappa_q, L\rangle \ \text{ for } \ q = d, s, b, \end{cases} \quad Y|\kappa_q, L\rangle = \begin{cases} +1|\kappa_q, L\rangle \ \text{ for } \ q = u, c, t, \\ -1|\kappa_q, L\rangle \ \text{ for } \ q = d, s, b. \end{cases} \tag{3}$$

The right-handed cen-quarks have isospin 0 and hypercharge 0.

3. The mass of each cen-quark is either zero or very small in comparison to the mass of the corresponding colored and electrically charged quark, i.e., $m_{\kappa_q} = 0$ or $m_{\kappa_q} \ll m_q$.

4. They participate in weak interactions mediated by very massive weak bosons, i.e., $W^{+\frac{2}{3}}$, $\overline{W}^{+\frac{2}{3}}$, Z_2^0, $W^{-\frac{1}{3}}$, $\overline{W}^{-\frac{1}{3}}$ and Z_3^0.

5. They carry away the 'missing energy' in decay processes as do neutrinos.

A. Weak Currents Involving κ_u, κ_c, κ_t

From the three column vectors

$$\Psi_{2i}^{L} = \begin{pmatrix} u_i^L \\ c_i^L \\ t_i^L \\ \kappa_u^L \\ \kappa_c^L \\ \kappa_t^L \end{pmatrix}, \tag{4}$$

where $i = r, g, b$, $q_i^L = P_L q_i$, $\kappa_q^L = P_L \kappa_q$, $(q = u, c, t)$, $P_L = \frac{1-\gamma^5}{2}$, we obtain the interaction term from the gauge invariant Lagrangian (see [1]),

$$\mathscr{L}_{\mathrm{I}_2} = -\frac{g}{2\sqrt{2}} \sum_{i=r,g,b} (W_{2i}^{\mu} J_{2i\mu} + W_{2i}^{\mu\dagger} J_{2i\mu}^{\dagger}) - [\frac{g}{\cos\theta_2}(J_{\mu 2}^{(T_3)} - \sin^2\theta_2 \frac{J_{\mu 2}^{(Q_2)}}{e}) Z_2^{\mu} + J_{\mu 2}^{(Q_2)} A^{\mu}], \tag{5}$$

where $W_{2i}^{\mu} = \frac{1}{\sqrt{2}}(W_{12i}^{\mu} - iW_{22i}^{\mu})$, of which the quanta correspond to $W_i^{+\frac{2}{3}}$ (or $W^{+\frac{2}{3}}$), and

$$J_{2i\mu} = 2\bar{\Psi}_{2i}^{L} \gamma_\mu H_2 \Psi_{2i}^{L},\ H_2 = \begin{pmatrix} 0 & U_2 \\ 0 & 0 \end{pmatrix}, \tag{6}$$

where U_2 is a 3×3 unitary matrix, 0 the 3×3 null matrix.

The $\mathscr{L}_{\mathrm{I}_2}$ describes the interactions in which a charged current involving a cen-quark (κ_u, κ_c, κ_t) and a colored and electrically charged quark (u, c, t) is coupled to a colored and electrically charged gauge boson $W^{+\frac{2}{3}}$ or $\bar{W}^{+\frac{2}{3}}$, e.g.,

$$u_i \rightleftarrows \kappa_u + W_i^{+\frac{2}{3}}, \tag{7}$$

where $i = r, g, b$, and the interactions in which a neutral current is coupled to a colorless and electrically neutral gauge boson Z_2^0 corresponding to the quantum of the field Z_2^{μ}.

B. Weak Currents Involving κ_d, κ_s, κ_b

From the three column vectors

$$\Psi^L_{3i} = \begin{pmatrix} \kappa^L_d \\ \kappa^L_s \\ \kappa^L_b \\ d^L_i \\ s^L_i \\ b^L_i \end{pmatrix}, \tag{8}$$

where $i = r, g, b$, $q^L_i = P_L q_i$, $\kappa^L_q = P_L \kappa_q$, $(q = d, s, b)$, we obtain (see [1])

$$\mathscr{L}_{\mathrm{I}_3} = -\frac{g}{2\sqrt{2}} \sum_{i=r,g,b} (W^{\mu\dagger}_{3i} J_{3i\mu} + W^{\mu}_{3i} J^{\dagger}_{3i\mu}) - [\frac{g}{\cos\theta_3}(J^{(T_3)}_{\mu 3} - \sin^2\theta_3 \frac{J^{(Q_3)}_{\mu 3}}{e}) Z^{\mu}_3 + J^{(Q_3)}_{\mu 3} A^{\mu}], \tag{9}$$

where $W^{\mu}_{3i} = \frac{1}{\sqrt{2}}(W^{\mu}_{13i} + iW^{\mu}_{23i})$, of which the quanta correspond to $W_i^{-\frac{1}{3}}$ (or $W^{-\frac{1}{3}}$), and

$$J_{3i\mu} = 2\bar{\Psi}^L_{3i}\gamma_\mu H_3 \Psi^L_{3i},\ H_3 = \begin{pmatrix} 0 & U_3 \\ 0 & 0 \end{pmatrix}, \tag{10}$$

where U_3 is a 3×3 unitary matrix, 0 the 3×3 null matrix.

The $\mathscr{L}_{\mathrm{I}_3}$ describes the interactions in which a charged current involving a cen-quark (κ_d, κ_s, κ_b) and a colored and electrically charged quark (d, s, b) is coupled to a colored and electrically charged gauge boson $W^{-\frac{1}{3}}$ or $\bar{W}^{-\frac{1}{3}}$, e.g.,

$$d_i \rightleftarrows \kappa_d + W_i^{-\frac{1}{3}}, \tag{11}$$

where $i = r, g, b$, and the interactions in which a neutral current is coupled to a colorless and electrically neutral gauge boson Z^0_3 corresponding to the quantum of the field Z^{μ}_3.

III. NUMBER OF QUARK FLAVORS

The quarks are spin-$\frac{1}{2}$ and baryon number $\frac{1}{3}$ fermions. In addition to the known six colored and electrically charged quark flavors (u, c, t, d, s, b) introduced by Gell-Mann [2], Zweig [3], Greenberg [4] and others, our theory [1] also deals with six colorless and electrically neutral quark flavors (κ_u, κ_c, κ_t, κ_d, κ_s, κ_b). Thus the total number of quark flavors appearing in our theory is twelve, i.e., double the number of the known colored and electrically charged quark flavors: Six colored and electrically charged quark flavors plus six colorless and electrically neutral quark flavors.

Accordingly, quarks can be classified into four types and three generations:
(u-type: u, c, t), (κ_d-type: κ_d, κ_s, κ_b), (κ_u-type: κ_u, κ_c, κ_t), (d-type: d, s, b), and

$$G_{\mathrm{I}} = \begin{pmatrix} u \\ \kappa_d \\ \kappa_u \\ d \end{pmatrix}, G_{\mathrm{II}} = \begin{pmatrix} c \\ \kappa_s \\ \kappa_c \\ s \end{pmatrix}, G_{\mathrm{III}} = \begin{pmatrix} t \\ \kappa_b \\ \kappa_t \\ b \end{pmatrix}. \tag{12}$$

People may say that the number of quark flavors are already determined by the experiments determining the ratio

$$R \equiv \frac{\sigma(e^+e^+ \to \text{hadrons})}{\sigma(e^+e^+ \to \mu^+\mu^+)} = \sum_{q=\text{ quark species}} e_q^2. \tag{13}$$

However it can easily be seen that the experiments are so insensitive to the colorless and electrically neutral quarks that we cannot get any information for the colorless and electrically neutral quarks from the experiments. Furthermore, since the colorless and electrically neutral quarks do not participate in strong interactions, the number of color triplet quarks to maintain the asymptotic freedom in SU(3) color gauge theory is completely unrelated with the number of the colorless and electrically neutral quarks.

IV. CONCLUDING REMARKS

The novel feature of cen-quarks is that they participate neither in the strong interactions nor in the electromagnetic interactions, they participate exclusively in the weak interactions as do neutrinos (if we ignore the gravitational interactions), so that they carry away the missing energy in decay processes as do neutrinos.

For confirmation of our theory, we should look for the cen-quarks κ_u, κ_c, κ_t, κ_d, κ_s, κ_b, the weak bosons $W^{+\frac{2}{3}}$, Z_2^0, $W^{-\frac{1}{3}}$, Z_3^0, and their anti-particles, in similar ways as we searched for the neutrinos ν_e, ν_μ, ν_τ, and weak bosons $W^\pm$ and Z^0.

[1] E. H. Jeong, viXra:1302.0042 (2013).
[2] M. Gell-Mann, *Phys. Lett.* **8**, 214 (1964).
[3] G. Zweig, CERN:8182/TH.401 (1964).
[4] O. W. Greenberg, *Phys. Rev. Lett.* **13**, 598 (1964).