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Electroweak Interactions at an Infinite Sublayer Quark Level. IV. Composite Model of Electron, Neutrino, and Gauge Bosons

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We assume that the electron (e^-), neutrino (ν_e), and gauge bosons ($W^{\pm}$, Z^0) are composed of only two kinds of particles, an ultimate particle u_∞ at an infinite sublayer quark level and a chargeless fermion ι, such that $e^- = (u_\infty^{cp}\, u_\infty^{cp}\, \iota)$, $\nu_e = (u_\infty\, u_\infty^{cp}\, \iota)$, $W^+ = (u_\infty\, u_\infty)$, $W^- = (u_\infty^{cp}\, u_\infty^{cp})$, and $Z^0 = (u_\infty\, u_\infty^{cp})$. It is then shown that *CP* is violated in weak interactions associated with these electron, neutrino, and gauge bosons.

1. INTRODUCTION

In a previous paper (Sekine, 1985), the infinite sublayer quark model was proposed. It was assumed that quarks are made up of subquarks which are made up of more fundamental subquarks, etc. Thus, u_N and d_N quarks at level N are made up of u_{N+1} and d_{N+1} quarks at level $N+1$, such that $u_N = (u_{N+1}\, u_{N+1}\, d_{N+1})$ and $d_N = (u_{N+1}\, d_{N+1}\, d_{N+1})$, where $N = 1, 2, \ldots, \infty$. The limiting particle u_∞ has all one-half quantum numbers, that is, spin $J = 1/2$, isospin $I = 1/2$, third component of isospin $I_3 = 1/2$, and fractional electric charge $Q = (1/2)|e|$, where $|e|$ is the electron charge. The antiparticle of u_∞ is the d_∞ quark, since the baryon number vanishes at $N = \infty$. Thus, at $N = \infty$, an infinite number of pointlike quarks (u_∞) and antiquarks ($\bar{u}_\infty = d_\infty$) is considered as constituting the nucleon.

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We applied the electroweak model of $SU(2)_L \times U(1)$ to the interactions at the infinite sublayer quark level (Sugita *et al.*, 1991, 1992; Okamoto *et al.*, 1992). By considering the weak isospin doublets $(u_{\infty L}\, u^{cp}_{\infty L})^T$ and $(u_{\infty L}\, u^{ct}_{\infty L})^T$, it was shown that *CP* is violated at an infinite sublayer quark level. Here $u^{cp}_{\infty L}$ means the left-handed particle operated on by charge conjugation C and then parity transformation P, and $u^{ct}_{\infty L}$ that operated on by charge conjugation C and then time reversal t. The superscript T means transposed.

In the following, we consider the composite model of electron, neutrino, and gauge bosons at an infinite sublayer quark level and show that *CP* is violated even in pure leptonic interactions involving electron, neutrino, and gauge bosons.

2. COMPOSITE MODEL OF ELECTRON, NEUTRINO, AND GAUGE BOSONS

Within the framework of the electroweak theory of Glashow (1961), Weinberg (1967), and Salam (1968), a quark current $\bar{u}_N \gamma_\mu [(1-\gamma_5)/2] d_N$ at a quark level N couples to the weak vector boson W^+ as

$$(d_N)_L + W^+ \rightarrow (u_N)_L \tag{1}$$

From the infinite sublayer quark model at $N=\infty$, equation (1) is a consequence of the following process:

$$(d_\infty)_L + W^+ \rightarrow (u_\infty)_L \tag{2}$$

The ultimate particles u_∞ and $d_\infty = \bar{u}_\infty$ are structureless. Therefore, if the gauge boson W^+ is a composite particle, it is natural to consider that W^+ is composed of $u_{\infty L}$, such that $W^+ = (u_{\infty L}\, u_{\infty L})$. Furthermore, from the process $e^+_L\, e^-_L \rightarrow W^+ W^-$ which is mediated by the gauge boson Z^0, and the process $e^-_L\, \nu_{eL} \rightarrow \nu_{eL}\, e^-_L$ mediated by W^-, we can assume that $W^- = (u^{cp}_{\infty L}\, u^{cp}_{\infty L})$, $Z^0 = (u_{\infty L}\, u^{cp}_{\infty L})$, $e^-_L = (u^{cp}_{\infty L}\, u^{cp}_{\infty L}\, \iota_L)$ and $\nu_{eL} = (u_{\infty L}\, u^{cp}_{\infty L}\, \iota_L)$, where ι is a chargeless particle with spin 1/2.

In a previous paper (Sugita *et al.*, 1992), it was shown that *CP* is violated, insofar as we consider the weak isospin doublets $(u_{\infty L}\, u^{cp}_{\infty L})^T$ and $(u_{\infty L}\, u^{ct}_{\infty L})^T$. For example, consider the doublet $(u_{\infty L}\, u^{cp}_{\infty L})^T$. Since $u_{\infty L}$ and $u^{cp}_{\infty L}$ are not independent of each other, we can write

$$u^{cp'}_{\infty L} = e^{i\delta} u^{cp}_{\infty L} \tag{3}$$

and the phase factor $e^{i\delta}$ cannot be eliminated by redefining the phase of $u_{\infty L}$. The presence of this uneliminated phase results in *CP* violation. Thus, if electron, neutrino, and gauge bosons are composed of $u_{\infty L}$, $u^{cp}_{\infty L}$, and ι_L, it

is then concluded that *CP* is violated even in pure leptonic interactions associated with electron, neutrino, and gauge bosons.

3. CONCLUSIONS

We considered that electron, neutrino, and gauge bosons are composed as follows:

$$e_L^- = (u_{\infty L}^{cp}\, u_{\infty L}^{cp}\, \iota_L), \qquad \nu_{eL} = (u_{\infty L}\, u_{\infty L}^{cp}\, \iota_L)$$

$$W^+ = (u_{\infty L}\, u_{\infty L}), \qquad W^- = (u_{\infty L}^{cp}\, u_{\infty L}^{cp}), \qquad Z^0 = (u_{\infty L}\, u_{\infty L}^{cp})$$

It is then shown that *CP* is violated in weak interactions involving these electron, neutrino, and gauge bosons.

We did not consider the mechanism of the binding force of $u_{\infty L}$ and ι_L. One of the possibilities is to assume that the binding force originates from the hypercolor force. We considered the first generation of $(u\, d)^T$ and $(\nu_e\, e^-)^T$. The second and third generations are assumed to be excited states of the first generation.

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