Remarks on a composite model for leptons, quarks, and Higgs mesons

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Ideas for the composite model for leptons, quarks, and Higgs mesons previously proposed are clarified. A slight modification of the model to satisfy the anomaly-matching conditions is discussed. Remarks on the Vafa-Witten theorem for the vectorlike composite model are also presented.

The composite model for leptons, quarks, and Higgs mesons previously proposed[1] is based on the following fundamental points.[2]

(i) Up to the Planck mass ($\sim 10^{19}$ GeV) from the present energy scale (~ 100 GeV) there may exist more than two sublevels inside of leptons and quarks.

(ii) The next sublevel of leptons and quarks will appear in energies much lower than the grand-unified-theory energy scale ($\sim 10^{15}$ GeV). Then the breaking processes of baryon number and lepton number may not be the subject of the next level but of one of the deeper sublevels. (The lepton number and the quark number are conserved independently in the next sublevel.)

(iii) The effects of such deeper sublevels will be observed as nongauge couplings of preons in the next sublevel, as the Yukawa couplings of Higgs scalars in the standard model[3] may be understood as effective couplings induced by the dynamics of the next sublevel.

(iv) This procedure should be repeated in the deeper sublevels, unless all interactions in the sublevel are written in terms of gauge interactions. (Supersymmetry may be realized if the model has scalar preons in the last sublevel.)

Before we discuss details, let us briefly review the model. The preons are written in terms of the following representations of the left-right-symmetric gauge group

$$G \equiv SU(3)_H \otimes SU(3)_c \otimes SU(2)_L \otimes SU(2)_R \otimes U_{B-L}(1) ,$$

where $SU(3)_H$ and $SU(3)_c$, respectively, stand for hypercolor and color interactions.

	$SU(3)_H$	$SU(3)_c$	$SU(2)_L$	$SU(2)_R$	N_{B-L}	J^P
$t^l_{L(R)}$	3	3	2(1)	1(2)	-1	$\frac{1}{2}^+$
$t^q_{L(R)}$	3	$\bar{3}$	2(1)	1(2)	$\frac{1}{3}$	$\frac{1}{2}^+$
S^0	3	3	1	1	0	0^+

(1)

In (1), N_{B-L} and J^P, respectively, represent the $B-L$ number and $(\text{spin})^{\text{parity}}$ of particles. The preons t^l and t^q are, respectively, described by the charge doublets $(t^{l(0)}, t^{l(-1)})$ and $(t^{q(2/3)}, t^{q(-1/3)})$, where Q in $t^{a(Q)}$ denotes the electric charge of t^a. The most important point of the model is the introduction of the scalar preon S^0. As was discussed in Ref. 1, the scalar preon should be represented by bound states of fermions in a deeper sublevel, and the structure of S^0 is closely connected to the number of fermion generations. From the viewpoint given in (iii) the model will have some nongauge couplings. For instance, the self-coupling of S^0 can be written as $g_S S^0 S^0 S^0$, which is the singlet representation of the gauge group G and breaks the conservation of the S^0 number. Presumably the S^0 number will be explicitly broken via the self-interaction, which was not pointed out in the previous works.

Similar discussions can be made for the Vafa-Witten theorem for the vectorlike composite model.[4] In order to avoid the theorem we may introduce another scalar meson, S_8, represented by the $(8,1,2,2,\ N_{B-L}=0)$ representation of the gauge group G. We can take Yukawa couplings with the preons t^l and t^q as $\sum_{a=l,q} g_a \bar{t}^a_R S_8 t^a_L + \text{H.c.}$ This interaction does not induce any mass terms of t^a being invariant under G, because only even numbers of S_8 are in the singlet of G, and even numbers of S_8 cannot change left-handed particles to right-handed ones, or right-handed ones to left-handed ones. The S_8 meson may have a mass. The existence of such mesons is quite reasonable because many heavy mesons composed of new preons of a deeper sublevel, such as the structure of S^0 given in Ref. 2, may naturally be introduced. Introduction of such mesons does not change the spectrum of bound states composed of t^l, t^q, and S^0 at all, and may only add many new bound states with heavy masses. As far as the Higgs coupling is concerned, such heavy states can possibly have a role, as was discussed for the difference between the Higgs couplings of the u-quark series $(u,c,t,\ldots)$ and d-quark series $(d,s,b,\ldots)$ by Chang, Mohapatra, Pal, and Pati.[5] We do not need to take account of the theorem seriously.

It is easily seen that the model given in (1) has anomalies. In order to satisfy the so-called anomaly-matching condition,[6] the $SU(3)_H$-singlet preons must be introduced. We, however, see that a serious problem arises for the interpretation of them. A simple modification of the model for satisfying the anomaly-matching condition can be done by the change of the $SU(3)_c$ representations of preons, that is, by giving the singlet representation of $SU(3)_c$ to t^l and S^0, and the triplet one to t^q instead of the choice of (1):

Preons	$t^l_{L,R}$	$t^q_{L,R}$	S^0
$SU(3)_c$	1	3	1

(2)

With this choice the model is anomaly-free. Then we have no constraint on the number of generations. It is easily seen that this change does not change the discussions given in Ref. 1, except that the octet bound states of $SU(3)_c$ appear only in the $t^q\bar{t}^q$ bound states, while the octet state also appears in the $t^l\bar{t}^l$-bound states for the choice of (1). It is trivial that the discussion for the spontaneous parity violation of the model[7] is not changed at all, because all Higgs mesons used in Ref. 7 are in the singlet of $SU(3)_c$. The important change appears in the corrections of Higgs couplings in evaluating masses.[8] We shall see that the choice of (2) gives a better interpretation to masses.[8]

Finally, I would like to comment on another possibility of changing the model. Up to now the model is discussed in the left-right-symmetric scheme. We can easily change the model into a model with the left-right-asymmetric gauge. A simple example with the gauge group $SU(3)_H \otimes SU(3)_c \otimes SU(2)_L \otimes U(1)$ is given by the following choice of preons:

	$SU(3)_H$	$SU(3)_c$	$SU(2)_L$
$t_L^l = \begin{pmatrix} t_L^{l(0)} \\ t_L^{l(-)} \end{pmatrix}$	3	1	2
$t_R^{l(0)},\ t_R^{l(-)}$	3	1	1
$t_L^q = \begin{pmatrix} t_L^{q(2/3)} \\ t_L^{q(-1/3)} \end{pmatrix}$	3	3	2
$t_R^{q(2/3)},\ t_R^{q(-1/3)}$	3	3	1
S^0	3	1	1

(3)

In this model we need not introduce more mesons like S_8. That is to say, the model can be described only in terms of the gauge interactions. This choice can possibly be the model of the last sublevel, if the baryon number and the lepton number are not broken at all. It is easily seen that almost all results derived from the model of (1)[1,7] survive with this choice if we take into account the difference of the $SU(2)_R$ representation of bound states. This case, however, has a Nambu-Goldstone boson discussed by Chikashige, Mohapatra, and Peccei, which is shown to be harmless.[9] The mechanism giving tiny masses to neutrinos[10] is shut out from the model because there is no existence of the right-handed weak bosons.

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