Low-energy electroweak model from $E_6 \times E_6'$ preons

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A low-energy electroweak symmetry group is proposed from an $E_6 \times E_6'$ preon model which leads to $SU(3)_C \times SU(2)_L \times SU(2)_R \times U(1)_{YL} \times U(1)_{YR}$ where $SU(2)_R$ can either be the usual left-right-symmetric model group or an "inert $SU(2)_R$" with electromagnetically neutral gauge bosons. Additional discrete symmetries proposed in E_6 models are obtained as a transformation of preons and conservation of quantum numbers. Among the results of this model are (i) the existence of two effective scales, metacolor ($\Lambda_M \sim 10^{14}$ GeV) and hypercolor Λ_H (1 TeV), (ii) preon substructures for vector leptons (both right and left handed), (iii) $B-L$ number $\frac{1}{3}$ for the g quark, (iv) neutral composite Higgs scalar bosons, and (v) small mixing angles between $(E_{\bar{d}}^-, e^-), (d,g)$ states and neutrino mixing.

I. INTRODUCTION

Recently, several interesting phenomenological tests[1] have been proposed for signals of new vector bosons, vector leptons, and heavy scalars which are predicted by superstring-inspired E_6 models.[2] These models include theories with $E_8 \times E_8'$ internal gauge symmetry,[3] where one E_8 factor reduces to the E_6 gauge group. The E_6 is further broken to some subgroup at the Planck scale, including a maximal subgroup $[SU(3)]^3$. An interesting candidate for low-energy electroweak symmetry is the subgroup

$$G_{LR} = SU(3)_C \times SU(2)_L \times U(1)_{YL} \times SU(2)_R \times U(1)_{YR}$$

which is obtained from $SU(3)_R \supset SU(2)_R \times U(1)$, where the subgroup $SU(2)_R$ is "inert" and its generators commute with electric charge.[4] However, the E_6 models require additional assumptions for $\mathbf{27}, \overline{\mathbf{27}}$ Higgs scalar bosons, the presence of E_6-singlet fermion, the requirement of discrete symmetries for Yukawa couplings in the supersymmetric version, etc.[5] These features can be investigated most conveniently by a supersymmetric preon model based on the $E_6 \times E_6'$ gauge group. The object of the present work is to propose such a model in which preons and not quarks and leptons are the basic matter multiplets. The model has two effective scales in common with a recent version of the preon model,[6] such that one scale is low (hypercolor $\Lambda_H \geq 1$ TeV) and the other high (metacolor $\Lambda_M \simeq 10^{14}$ GeV). The quark and lepton emerge as composites of preons with quantum numbers of **27**-plet representations of the maximal subgroup $[SU(3)]^3$ of E_6. The left-handed fermions are quarks and leptons belonging to (3,3,1), $(\bar{3},1,\bar{3})$, and $(1,\bar{3},3)$ of two types of $\mathbf{27}_L, \mathbf{27}_{\bar{R}}$ representations such that one contains antifermions of the other. In Sec. III we consider the substructures for quarks and leptons for an effective low-energy group

$$SU(3)_C \times SU(2)_L \times SU(2)_R \times U(1)_{YL} \times U(1)_{YR} .$$

In Sec. IV additional discrete symmetries $U(1)_{Q_1} \times U(1)_{Q_2}$ as well as $B-L$ quantum numbers are introduced. Sec. V deals with Higgs scalars, Yukawa couplings, and mixing among **27**-plet fermions in a preonic framework. Finally, Sec. VI is a short discussion on the results of the model.

II. THE MODEL

The essential idea of the model is that an effective E_6 group obtained from a locally supersymmetric preonic theory can explain many interesting consequences of phenomenological E_6. The preons belong to the maximal subgroup $[SU(3)]^3$ of E_6:

$$E_6 \supset SU(3)_M \times SU(3)_I \times SU(3)_{II} ,$$

where $SU(3)_M$ denotes metacolor while $SU(3)_I$ and $SU(3)_{II}$ are diagonal in flavor and color space.[6] At metacolor scale Λ_M this splits into flavor E_6,

$$E_6 \supset SU(3)_M \times SU(3)_L \times SU(3)_R ,$$

and color E_6',

$$E_6' \supset SU(3)_M \times SU(3)_H \times SU(3)_C .$$

Under these subgroups, the **27**-flavons (f) with spin-$\frac{1}{2}$ belong to

$$^{27}f = \underbrace{(^3M, {}^3L, {}^1R)}_{f_L} + \underbrace{(^{3^*}M, {}^1L, {}^{3^*}R)}_{f_R^c} + \underbrace{(^1M, {}^{3^*}L, {}^3R)}_{\xi_f}$$

in metacolor, left- and right-handed flavor spaces. The spin-0 chromons belong to a **27** of E_6';

$$^{27}C = \underbrace{(^3M, {}^3H, {}^1C)}_{C_{II}} + \underbrace{(^{3^*}M, {}^1H, {}^{3^*}C)}_{C_I^*} + \underbrace{(^1M, {}^{3^*}H, {}^3C)}_{\xi_C}$$

in metacolor, hypercolor, and QCD color spaces. The metacolor $SU(3)_M$ forces become strong at a momentum scale Λ_M, where 1 TeV $\ll \Lambda_M \ll M_{Pl}$, and physical fermions are metacolor-singlet composites. We consider a supersymmetric framework with both $^3M, {}^{3^*}M$ spin-$\frac{1}{2}$

flavons (f) and spin-0 chromons (c). The ξ preons are ^1M and do not couple to physical states.

The bound states (fC^*V) and (fC^*VV) are massless and of both left- and right-handed types where V_M are metagluons as suggested in Ref. 6. These give quark substructures $(f_L C_{\rm I}^* V)$, $(f_R C_{\rm I}^* V)$ as well as hyperfermions $(f_L C_{\rm II}^* V)$, $(f_R C_{\rm II}^* V)$. The anomaly-matching conditions[6] are satisfied according to the flavon-chromon model, since they vanish both at the preon and quark level.

For leptons we consider hypercolor forces to be strong at a momentum scale $\Lambda_H \geq 1$ TeV, so that three-hyperfermion composites of both left- and right-handed types, with spin-$\frac{1}{2}$ and ^1H, give lepton substructures.[7] For anomaly-matching conditions[8] at pointlike hyperfermion and lepton composite levels, a mass term $m\overline{\Psi}_L\Psi_R$ has to be introduced for hyperfermion with third flavor so that leptons containing this flavor are massive. Both left- and right-handed leptons with substructures

$$[f_L^c(f_R^c,f_R^c)_A 3C_{\rm II}],\quad [f_R(f_L,f_L)_A 3C_{\rm II}^*]\ ,$$

$$[f_L(f_R,f_R)_A 3C_{\rm II}^*]\ ,$$

and

$$[f_R^c(f_L^c,f_L^c)_A 3C_{\rm II}]\ ,$$

respectively, are obtained in this model. The family-replication problem in the preon model essentially depends on preon dynamics. However, even metagluon excitations (fC^*VV) of two types of metacolor singlets in $8\otimes 8\otimes 8$ allow for second and third generations of quark and hyperfermions.

III. LEFT-RIGHT-SYMMETRIC MODEL AND $\widetilde{\rm SU}(2)_R$ SYMMETRY

In the low-energy region, an effective E_6 gauge symmetry is turned on such that

$$E_6 \supset {\rm SU}(3)_C\times {\rm SU}(3)_L\times {\rm SU}(3)_R$$

$$\supset {\rm SU}(3)_C\times{\rm SU}(2)_L\times{\rm SU}(2)_R\times {\rm U}(1)_{YL}\times{\rm U}(1)_{YR}\ .$$

All the left-handed preon composites have quantum numbers of **27**-plet representation, while the right-handed composites belong to $\overline{\mathbf{27}}$-plet as will be shown below. For flavons we consider $f_L(f_{uL},f_{dL},f_{gL})$ and $f_R^c(f_{uR}^c,f_{dR}^c,f_{gR}^c)$ with ${\rm SU}(2)_L$-spin $I_{3L}=+\frac{1}{2},-\frac{1}{2},0$ and $Y_L=\frac{1}{6},\frac{1}{6},-\frac{1}{3}$ for f_L. There is a choice for ${\rm SU}(2)_R$, the usual LR-symmetric model giving $I_{3R}=+\frac{1}{2},-\frac{1}{2},0$ and $Y_R=\frac{1}{6},\frac{1}{6},-\frac{1}{3}$ for $f_R(f_{uR},f_{dR},f_{gR})$. The charge operator $Q=I_{3L}+Y_L+I_{3R}+Y_R$ so that $Q=\frac{2}{3},-\frac{1}{3},-\frac{1}{3}$ for $(f_u,f_d,f_g)_{L,R}$ and $Q=0$ for chromons $(C_{\rm I},C_{\rm II})$.

A second choice for ${\rm SU}(3)_R$ breaking is the subgroup $\widetilde{\rm SU}(2)_R$ or "inert" ${\rm SU}(2)_R$ according to which $I_{3\tilde R}=+\frac{1}{2},-\frac{1}{2}$ for (f_{dR}^c,f_{gR}^c) and $I_{3\tilde R}=0$ for f_{uR}^c, while $Y_{\tilde R}=\frac{1}{6},\frac{1}{6},-\frac{1}{3}$ for $(f_{dR}^c,f_{gR}^c,f_{uR}^c)$. Here $2Y_{\tilde R}=I_{3R}+Y_R$, and $Q=I_{3L}+Y_L+2Y_{\tilde R}$. The object of introducing $\widetilde{\rm SU}(2)_R$ in the preon model is to investigate the consequences of a discrete P symmetry[5] under which $L\leftrightarrow\tilde R$ such that $f_{uL}\leftrightarrow f_{dR}^c$, $f_{dL}\leftrightarrow f_{gR}^c$, $f_{gL}\leftrightarrow f_{uR}^c$, $C_{\rm I}\leftrightarrow C_{\rm I}^*$, $C_{\rm II}\leftrightarrow C_{\rm II}^*$. For quarks we consider $(fC_{\rm I}^*V)$ composites, transforming as 3_c,

$$u_L,d_L=(f_{uL},f_{dL})C_{\rm I}^*\ ,$$

$$u_R^c,d_R^c=(f_{uR}^c,f_{dR}^c)C_{\rm I}\ ,$$

$$g_L=f_{gL}C_{\rm I}^*,\quad g_R^c=f_{gR}^cC_{\rm I}\ .$$

These belong to $(3_c,3_L,I_R)$ and $(3_c^*,I_L,3_R^*)$ representations. For leptons, the $(I_c,3_L^*,3_R)$ composites are of two types: $1_L=(L3C_{\rm II})_{1H}$, $1_{\tilde R}=(\tilde R 3C_{\rm II}^*)_{1H}$, where $L=f_L^c[f_R^c,f_R^c]_A$, $\tilde R=f_R[f_L,f_L]_A$,

$$L=[f_{dR}^c,f_{gR}^c][f_{gR}^c,f_{uR}^c][f_{uR}^c,f_{dR}^c]\ ,$$

f_{uL}^c	N_u	E_d^-	e^-
f_{dL}^c	E_u^+	N_d	ν_e
f_{gL}^c	e_R^c	ν_R^c	η_0

$$\tilde R=[f_{uL},f_{dL}][f_{dL},f_{gL}][f_{gL},f_{uL}]\ .$$

f_{dR}	ν_R^c	E_d^-	N_d
f_{gR}	η_0	e^-	ν_e
f_{uR}	e_R^c	N_u	E_u^+

The fermion assignments are made according to the low-energy group

$${\rm SU}(3)_c\times{\rm SU}(2)_L\times\widetilde{\rm SU}(2)_{\tilde R}\times{\rm U}(1)_{YL}\times{\rm U}(1)_{Y\tilde R}$$

as (a,b,c,d,e):

$$\begin{bmatrix}u_L\\ d_L\end{bmatrix}=Q_L(3,2,1,\tfrac{1}{6},0),\quad \begin{bmatrix}d^c\\ g^c\end{bmatrix}_R=D_R^c(3^*,1,2,0,\tfrac{1}{6})\ ,$$

$$g_L=(3,1,1,-\tfrac{1}{3},0),\quad u_R^c=(3^*,1,1,0,-\tfrac{1}{3})\ ,$$

$$\begin{bmatrix}E_u^+\\ N_u\end{bmatrix}=E(1,2,1,-\tfrac{1}{6},\tfrac{1}{3}),\quad \begin{bmatrix}\eta_0\\ \nu_R^c\end{bmatrix}=N(1,1,2,\tfrac{1}{3},-\tfrac{1}{6})\ ,$$

$$\begin{bmatrix}\nu_e & N_d\\ e^- & E_d^-\end{bmatrix}=(1,2,2,-\tfrac{1}{6},-\tfrac{1}{6}),\quad e_R^c=(1,1,1,\tfrac{1}{3},\tfrac{1}{3})\ .$$

In the preon model, under $L\leftrightarrow\tilde R$ symmetry, we obtain $Q_L\leftrightarrow D_R^c$, $g_L\leftrightarrow u_R^c$, and $1_L\leftrightarrow 1_{\tilde R}$. The requirement of an anomaly-matching condition gives massless lepton composites $(\nu_e,e^-)_L$ and $(\nu_R^c,e_R^c)_{\tilde R}$ containing $(fu,fd)_{L,R}$ preons. All other leptons containing $f_{gL,R}$ are massive. Thus the **27**-plet representation of effective E_6 contains two types of $\mathbf{27}_L,\mathbf{27}_{\tilde R}$ left-handed chiral fermions such that one contains the antifermions of the other. This will be reflected in the $B-L$ number to be defined later. Ordinary E_6 models do not distinguish between $L,\tilde R$ states and matter and antimatter share the same **27**-plet representation. The $\widetilde{\rm SU}(2)_R$ gauge bosons are electromagnetically neutral and give new $W_{\tilde R}$ as well as $Z_{\tilde R}$ particles. The neutral generators[1] of effective E_6 are related, in the notation of Aguila, Quiros, and Zwirner, in the following manner:

$$T_{3L}=I_{3L}, \quad \sqrt{5/3}Y=Q-I_{3L} ,$$

$$\sqrt{5/3}Y'=2Y_L-Y_{\tilde{R}}, \quad Y''=I_{3\tilde{R}} .$$

A new operator $Q_1=2(Y_L-Y_{\tilde{R}})$ related to the $B-L$ number is introduced in the next section.

The model requires $\overline{27}_L,\overline{27}_{\tilde{R}}$ right-handed fermions containing $(f_R C_{\rm I}^* V),(f_L^c C_{\rm I} V)$ quarks and $[f_L(f_R,f_R)_A 3C_{\rm II}^*],[f_R^c(f_L^c,f_L^c)_A 3C_{\rm II}]$ leptons for anomaly-matching conditions.

IV. ADDITIONAL DISCRETE SYMMETRIES AND $B-L$ CONSERVATION

E_6 subgroups require the postulate of additional discrete symmetries to prevent proton decay and neutrino mixing which do not have deep sources in the topology of compactification space.[9] In the present model, we assign new quantum numbers $Q_1=2(Y_L-Y_{\tilde{R}})$, $\tilde{Q}_2=+1,-1$ for (f_{uR}^c,f_{gL}) flavons which are $\widetilde{\rm SU}(2)_R$,SU$(2)_L$ singlets. The combination $Q_1-\tilde{Q}_2$ is found to correspond to $B-L$ number:

$$Q_1-\tilde{Q}_2=(B-L)_L-(B^c-L)_{\tilde{R}} .$$

$Q_1=(\frac{1}{3},\frac{1}{3},-\frac{2}{3})$ for (f_{uL},f_{dL},f_{gL}) while $Q_1=(-\frac{1}{3},-\frac{1}{3},\frac{2}{3})$ for $(f_{dR}^c,f_{gR}^c,f_{uR}^c)$, respectively. The $g_L(f_{gL}C_{\rm I}^*)$ and $g_R^c(f_{gR}^c C_{\rm I})$ quarks are thus assigned $B-L=+\frac{1}{3},-\frac{1}{3}$, which is a significant departure from $B=-\frac{2}{3}$ in E_6 models.[5] For leptons, $B-L=-1=Q_1-\tilde{Q}_2$ for 1_L while $B-L=+1=Q_1-\tilde{Q}_2$ for $1_{\tilde{R}}$. This is possible for the case of leptons in 1_L and antileptons in $1_{\tilde{R}}$ as shown for $(e^-,\nu_e)_L$ and $(\nu_R^c,e_R^c)_{\tilde{R}}$. The model thus allows for a global $U(1)_{Q_1}\otimes U(1)_{\tilde{Q}_2}$ symmetry for the $L\tilde{R}$-symmetric model. The new Q_1 charge can manifest as a Z boson which aligns along $2(Y_L-Y_{\tilde{R}})$. Recently, a new Z_3 boson which decouples from e^-e^+ and aligns along $(1/\sqrt{10})(Y-3Y')$ has been predicted from phenomenological E_6 models.[1] This Z_3 boson arises naturally as along $-\sqrt{3/8}Q_1$ in the present case.

For LR-symmetric model, we assign $Q_2=+1,-1$ to SU$(2)_L$,SU$(2)_R$ singlets (f_{gL}^c,f_{gR}) so that the charge operator

$$Q=I_{3L}+I_{3R}+\frac{B-L}{2}+\frac{Q_2}{2} .$$

The values of Q_2 for quarks are $(0,0,-1)$ and $(0,0,+1)$ for $(u,d,g)_L$ and $(u^c,d^c,g^c)_R$, respectively. For lepton composites, Q_2 denotes the amount of heavy $(f_g C_{\rm II}^* V)$ components, and are listed in Table I.

For the $\widetilde{\rm SU}(2)_R$ gauge group, $W_{\tilde{R}}$ bosons are exchanged among

$$\begin{bmatrix} E_d^- \\ e^- \end{bmatrix}, \quad \begin{bmatrix} N_d \\ \nu_e \end{bmatrix}, \quad \begin{bmatrix} \nu_R^c \\ \eta_0 \end{bmatrix},$$

while SU$(2)_L$ gauge bosons W_L are exchanged among

TABLE I. Values of $B-L$ number and new Q_2 charge for composite leptons where $Q_2=+1,-1$ for (f_{gL}^c,f_{gR}) preons and charge operator $Q=I_{3L}+I_{3R}+B-L/2+Q_2/2$ as defined in Sec. III.

$1_L;1_{\tilde{R}}$	$(B-L)_L-(B^c-L)_{\tilde{R}}$	Q_2
$(e^-,\nu_e)_L$	-1	0
$(E_d^-,N_d)_L$	-1	$+1$
$(E_u^+,N_u)_L$	-1	$+1$
$(e_R^c,\nu_R^c)_L$	-1	$+2$
η_{0L}	-1	$+1$
$(E_d^-,N_d)_{\tilde{R}}$	$+1$	-1
$(E_u^+,N_u)_{\tilde{R}}$	$+1$	-1
$(e_R^c,\nu_R^c)_{\tilde{R}}$	$+1$	0
$(e^-,\nu_e)_{\tilde{R}}$	$+1$	-2
$\eta_{0\tilde{R}}$	$+1$	-1

$$\begin{bmatrix} \nu_e \\ e^- \end{bmatrix}, \quad \begin{bmatrix} N_d \\ E_d^- \end{bmatrix}, \quad \begin{bmatrix} E_u^+ \\ N_u \end{bmatrix},$$

as seen from $L,\tilde{R}$ substructures. The e_R^c is a SU$(2)_{L,\tilde{R}}$ singlet, $(\nu_R^c;\eta_0)$ are SU$(2)_L$ singlets and $(E_u^+;N_u)$ are $\widetilde{\rm SU}(2)_R$ singlets. These are due to $({}^1C,{}^{3*}L,{}^3R)$ assignments and we do not obtain any new result.

V. HIGGS SCALAR BOSONS AND YUKAWA COUPLINGS

The essential requirement for anomaly-free theory of composite leptons is a scalar boson

$$\langle f_{gL}^c C_{\rm II} f_{gR} C_{\rm II}^* \rangle_{1H}=\langle \tilde{\eta}_0 \rangle$$

with large vacuum expectation value (VEV) so as to make all leptons containing $(f_g C_{\rm II}^*)_{L,R}$ massive. The neutral scalar bosons with small VEV's are introduced as

$$\langle f_{uL}^c C_{\rm II} f_{uR} C_{\rm II}^* \rangle_{1H}=\langle \tilde{N}_u \rangle$$

and

$$\langle f_{dL}^c C_{\rm II} f_{dR} C_{\rm II}^* \rangle_{1H}=\langle \tilde{N}_d \rangle .$$

We introduce

$$\langle \tilde{\nu}_e \rangle=\langle f_{dL}^c C_{\rm II} f_{gR} C_{\rm II}^* \rangle_{1H}$$

while

$$\langle \tilde{\nu}_R^c \rangle=\langle f_{gL}^c C_{\rm II} f_{dR} c_{\rm II}^* \rangle_{1H}=0 .$$

This rotates the multiplets from $\mathbf{27}_L\leftrightarrow\mathbf{27}_{\tilde{R}}$ in the present model. The Yukawa couplings of left-handed fields to neutral Higgs bosons are listed as $\mathcal{L}_Q,\mathcal{L}_1$ where

$$\mathcal{L}_Q=F_u u_L u_R^c \tilde{N}_u+F_d d_L d_R^c \tilde{N}_d+F_g g_L g_R^c \tilde{\eta}_0+F d_L g_R^c \tilde{\nu}_e ,$$

$$\mathcal{L}_1=g_1 e e_R^c \tilde{N}_d+g_2 \nu_e \nu_R^c \tilde{N}_u+G_1(E_d E_u \tilde{\eta}_0+N_d N_u \tilde{\eta}_0)+G_2(N_d \eta_0 \tilde{N}_u+N_u \eta_0 \tilde{N}_d)+G_3(e_R^c E_d \tilde{\nu}_e+\nu_R^c N_u \tilde{\nu}_e) .$$

The quark masses $M_u=F_u\langle \tilde{N}_u \rangle$, $M_d=F_d\langle \tilde{N}_d \rangle$, and $M_g=F_g\langle \tilde{\eta}_0 \rangle$. However, for leptons, $M_e=g_1\langle \tilde{N}_d \rangle$ and $M_\nu=0=g_2$. The presence of $(f_g C_{\rm II}^*)_{L,R}$ gives $M\propto\langle \tilde{\eta}_0 \rangle$

for $(E_d,E_u,N_d,N_u)_{L,\tilde{R}}$, while exotic leptons $(\nu_e,e^-)_{\tilde{R}}$, $(\nu_R^c,e_R^c)_L$ with $Q_2=\pm 2$ have $M \propto 2\langle\tilde{\eta}_0\rangle$. An advantage of the preon formalism is seen for the Dirac matrices if we introduce (f_d,f_g) mixing among flavons, in a universal seesaw mechanism:

$$(f_{dL},f_{gL})\quad M=\begin{bmatrix}\tilde{N}_d & \tilde{\nu}_e \\ 0 & \tilde{\eta}_0\end{bmatrix}\begin{bmatrix}f_{dR}^c \\ f_{gR}^c\end{bmatrix} .$$

This gives M^+, M^0 for leptons as obtained from substructures

$$(e_R^c,E_u)_{\tilde{R}}\quad M^+=\begin{bmatrix}m_1 & M_1 \\ 0 & M_2\end{bmatrix}\begin{bmatrix}e^- \\ E_d^-\end{bmatrix}_L ,$$

$$(\nu_R^c,N_u)_{\tilde{R}}\quad M^0=\begin{bmatrix}0 & M_1 \\ 0 & M_2\end{bmatrix}\begin{bmatrix}\nu_e \\ N_u+N_d\end{bmatrix}_L .$$

Here $m_1=g_1\langle\tilde{N}_d\rangle$, $M_1=G_3\langle\tilde{\nu}_e\rangle$, and $M_2=G_1\langle\tilde{\eta}_0\rangle$. The $\nu_R^c\nu_e\tilde{N}_d$ coupling vanishes due to substructures and $\langle\tilde{N}_u\rangle$ is not relevant in this matrix. The rotation $\tan\theta=M_1/M_2$ is proportional to $\langle\tilde{\nu}_e\rangle:\langle\tilde{\eta}_0\rangle$. This has been calculated to obtain mixing angles in E_6 models,[1] $\Theta_L^E=(m_1/M_2)^2\tan\theta$ and $\Theta_R^E=(m_1/M_2)\tan\theta$. The same (f_{dL},f_{gL}) mixing can give mixing angles for d_L,g_L quarks:

$$(d_L,g_L)\quad M_Q=\begin{bmatrix}m_3 & M_3 \\ 0 & M_4\end{bmatrix}\begin{bmatrix}d_R^c \\ g_R^c\end{bmatrix} ,$$

where $m_3=M_d$, $M_3=F\langle\tilde{\nu}_e\rangle$, and $M_4=F_g\langle\tilde{\eta}_0\rangle=M_g$. The mixing angles[5] are $\alpha_L=\tan\theta'(M_d/M_g)$ and $\alpha_R=\tan\theta'$ where

$$\tan\theta'=\frac{F}{F_g}\frac{\langle\tilde{\nu}_e\rangle}{\langle\tilde{\eta}_0\rangle} .$$

VI. CONCLUSIONS

We have introduced a $E_6 \times E_6'$ group for preons such that by considering physical particles as metacolor and hypercolor composites, it is possible to obtain preon substructures for the **27**-plet quark and leptons of the usual E_6 model. The $B-L$ number is obtained as $Q_1-\tilde{Q}_2$, which gives $B-L=\frac{1}{3}$ for (u,d,g) quarks and $B-L=-1,+1$ for all leptons. The new charge Q_1 is predicted to give a new Z_3 boson which decouples from 1^+1^- as also seen from phenomenological E_6 models. The mixing between (f_{dL},f_{gL}) preons lead to mixing among $\mathbf{27}_L,\mathbf{27}_{\tilde{R}}$ multiplets of left-handed matter fields. A basic difference with E_6 theory is the existence of two **27**-plets, which are indistinguishable for quarks but give only $(\nu_e,e^-)_L$, $(e_R^c,\nu_R^c)_{\tilde{R}}$ leptons at low energies. In addition, right-handed quarks and leptons are given in $\overline{\mathbf{27}}$-plet representations. An interesting substructure is obtained for neutral Higgs scalar boson at $\Lambda_H>1$ TeV momentum scale. The question of family replication and generation mixing among (fC^*V), (fC^*VV) quarks depends on preon dynamics,[10] and is not crucial for our formalism. The low-energy gauge symmetry

$$SU(3)_C\times SU(2)_L\times SU(2)_R\times U(1)_{YL}\times U(1)_{YR}$$

does not distinguish between different metacolor and hypercolor composites, but VEV's of Higgs scalars can be different in ratios of

$$m_u:m_c:m_t=m_{g1}:m_{g2}:m_{g3} .$$

The model is an alternative to the flavon-chromon model with lepton color, although incorporating the basic preonic formalism, and allows a phenomenological basis for studying the exotic fermions of the E_6 model.

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