THE $E_6 \otimes SO(10)$ PREON MODEL BASED ON GLOBAL SU(18) COLOR–FLAVOR

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We have constructed a version of the chiral three-preon model $E_6 \otimes SO(10)$ based on the global color–flavor symmetry group SU(18). By applying the 't Hooft anomaly matching condition to the subgroup SU(16)×SU(2) of SU(18) together with a few physical constraints, we obtain a unique solution that gives rise to three generations of the spinorial representation 16 of SO(10) without exotics. Except for $N = 18$, no solution at all exists for the global color–flavor group SU(N) ($16 < N < 22$) when SU(N) breaks to SU(16)×SU($N - 16$).

The $E_6 \otimes SO(10)$ preon model was first derived [1] [‡1] as the unique chiral three-fermion preon model on the basis of some fairly general conditions. One starts with $G_{MC} \otimes G_{CF}$, where G_{MC} is a simple metacolor group and $G_{CF} = U(N)$ is the largest global color–flavor group, part of which must be gauged. It can then be shown that $G_{MC} = E_6$ and that the gauged color–flavor subgroup is SO(10) (with $N = 16$) if one insists on single irreducible representations of both the metacolor and color–flavor groups as well as asymptotic freedom in the metacolor sector. In the GTM $E_6 \otimes SO(10)$ model, three families are predicted if SO(10) descends through the phenomenologically interesting $SU(4)_c \times SU(2)_L \times SU(2)_R$ group [2]. The chief drawback of this $E_6 \otimes SO(10)$ model is the predicted superabundance of exotic fermions and the consequent loss of asymptotic freedom in the composite color–flavor sector.

Recently, Silveira and Zee have proposed [3] a new version of the $E_6 \otimes SO(10)$ preon model in which they start with SU(27) as the global color–flavor symmetry group. These authors end up with the same gauged SO(10) color–flavor subgroup and, in the process, make constructive use of the 't Hooft anomaly matching condition [4] to eliminate undesirable exotics. However, it seems to us that their willingness to surrender asymptotic freedom in the metacolor sector – through the use of SU(27) – is too steep a price to pay. Furthermore, we differ from Silveira and Zee and agree with Bars [5] that in the application of the 't Hooft anomaly matching condition no index with absolute value greater than unity should be allowed and that the meta-Pauli principle should be imposed.

Keeping these last three points in mind, we have searched for a version of the $E_6 \otimes SO(10)$ preon model (in the spirit of Silveira and Zee) that retains metacolor asymptotic freedom, that gives a unique solution to the 't Hooft condition with "Bars" indices and that predicts at least three families of ordinary quarks and leptons. We find that there is only one such model and this requires $G_{CF} = SU(18)$ so that the preons belong to the representation (27; 18) of (E_6; SU(18)). Since the 't Hooft condition is not satisfied for SU(18) when the meta-Pauli principle is imposed, this group must spontaneously break down to a subgroup H_{CF} which, in turn, contains gauged SO(10) as its subgroup. We take H_{CF} to be SU(16) × SU(2); the U(1) symmetry that would appear in the breakdown $G_{CF} \to H_{CF}$ is assumed to be dynamically broken by metacolor forces as in ref. [3]. We note that the Appelquist–Carazzone decoupling conditions [4] are not imposed here, since we cannot give E_6 invariant mass term to the preons.

The particle content of the model is summarized in table 1. The 't Hooft anomaly matching condition comes from the three SU(16) currents, (the SU(2) currents give no contribution) and we have:

‡1 We shall refer to this paper as GTM.

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Table 1

		E_6	SU(16)	SU(2)	Indices
preons	P_1	27	$\square$	1	
	P_2	27	1	$\square$	
composites	$P_1P_1P_1$	1	$\square\square\square$, $\begin{smallmatrix}\square\\\square\\\square\end{smallmatrix}$, $\begin{smallmatrix}\square\square\\\square\end{smallmatrix}$	1	l_1^+, l_1^-, l_1^0
	$P_1P_1P_2$	1	$\square\square$, $\begin{smallmatrix}\square\\\square\end{smallmatrix}$	$\square$	l_2^+, l_2^-
	$P_1P_2P_2$	1	$\square$	$\square\square$, $\begin{smallmatrix}\square\\\square\end{smallmatrix}$	l_3^+, l_3^-
	$P_2P_2P_2$	1	1	$\square\square\square$, $\begin{smallmatrix}\square\square\\\square\end{smallmatrix}$	l_4^+, l_4^0

$$209l_1^+ + 65l_1^- + 247l_1^0 + 40l_2^+ + 24l_2^- + 3l_3^+ + l_3^- = 27. \tag{1}$$

By the meta-Pauli principle[‡2], eq. (1) reduces to

$$247l_1^0 + 40l_2^+ + 24l_2^- + 3l_3^+ + l_3^- = 27. \tag{2}$$

Finally, with the Bars condition on the indices, namely $|l_i| \leqslant 1$, we obtain the *unique* solution

$$l_3^+ = l_2^- = 1, \tag{3}$$

with zero value for all other indices.

The above solution predicts two massless composite fermions, ($\square$, $\square\square$) and ($\begin{smallmatrix}\square\\\square\end{smallmatrix}$, $\square$), under (SU(16), SU(2)), which correspond to the SO(10) representations 3(16) and 2(120). The representation 120, however, is real, and fermions corresponding to 120 acquire large masses at the grand unification scale [6]. Hence, we are left with exactly three generations of the spinorial representation 16 of SO(10) without any exotics.

One objection to any version of the $E_6 \otimes SO(10)$ preon model would be that SO(10) is not asymptotically free in the preon color–flavor sector [7]. However, since we have been implicitly assuming that the scale of metacolor confinement Λ_{MC} is larger than Λ_{GUT}, the SO(10) coupling constant would only become large near or even above the Planck mass scale (using the usual renormalization group analysis). Because of the absence of exotic fermions in our version of the $E_6 \otimes SO(10)$ model, we have no problem with asymptotic freedom in the composite color–flavor sector.

In this note we have shown that in an $E_6 \otimes SO(10)$ preon model the 't Hooft anomaly matching scheme with a few physical constraints suggests the spontaneous breakdown of the global symmetry $G_{CF} = SU(18)$ into SU(16) × SU(2). The solution to the anomaly consistency equation uniquely predicts three generations of SO(10) GUT without exotics. In fact, if we start with $G_{CF} = SU(N)$ $(16 < N < 22)$, the subgroup, SU(16) × SU(N–16) does not yield any solution at all to the 't Hooft anomaly matching equation (except for $N = 18$). Details will be given elsewhere [8].

‡2 It should be pointed out that we use the meta-Pauli principle in a crucial way to obtain the unique solution to the anomaly matching equation, while the meta-Pauli principle does not play a vital role in the Silveira–Zee model [3].

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