Higgs Pain? Take a Preon! *

Jean-Jacques Dugne
Laboratoire de Physique Corpusculaire
Université Blaise Pascal de Clermont-Ferrand II
FR-63177 Aubière, France

Sverker Fredriksson, Johan Hansson
Department of Physics
Luleå University of Technology
SE-97187 Luleå, Sweden

Enrico Predazzi
Department of Theoretical Physics
Università di Torino
IT-10125 Torino, Italy

Abstract

The Higgs mechanism is the favourite cure for the main problem with electroweak unification, namely how to reconcile a gauge theory with the need for massive gauge bosons. This problem does not exist in preon models for quark and lepton substructure with composite $Z^0$ and $W$s, which, consequently, also avoid all other theoretical complications and paradoxes with the Higgs mechanism. We present a new, minimal preon model, which explains the family structure, and predicts several new, heavy quarks, leptons and vector bosons. Our preons obey a phenomenological supersymmetry, but without so-called squarks and sleptons, since this SUSY is effective only on the composite scale.

1 Introduction: Why Higgs pain?

The Higgs mechanism is the hitherto smartest, and maybe the only logically consistent construction that circumvents the serious problems caused by the

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massive weak gauge bosons.

This "medicine" has by now become a research field of its own, but the extended theoretical efforts have mostly revealed several new and unwanted secondary effects, while no experimental signals whatsoever have been found. This has not prevented Higgs workers from assuming that the Higgs is responsible for all fundamental masses, through phenomenological Yukawa couplings.

Among the many Higgs pains one should mention that

- one single Higgs does not seem enough. In some models there are many different Higgses.

- it is currently fashionable to assume even that the Higgs is composite, but it is not clear why a particle that is not even fundamental should be so important for the creation of mass in the Universe.

- the "mass-from-the-Higgs" mechanism raises more questions than it answers. For instance: What gives the Higgs its mass? How can the Higgs keep track of all different fundamental masses in the particle zoo? Therefore, one cannot hope to reduce the number of ad hoc parameters in particle physics with the help of a Higgs.

- there are already some very complicated medicines to cure those Higgs pains, the most celebrated one being supersymmetry (SUSY). Attractive as it might seem as a symmetry on its own, relating fermions and bosons, its main contribution to the Higgs mechanism is to help cancel some divergent processes.

- joining SUSY with the Higgs gives a "higgsino", which should exist in the real world only mixed with the photino and the zino (the SUSY partners of the photon and the $Z^0$) inside the so-called neutralino, which, in turn, is supposed to constitute the bulk of the cosmic dark matter. One might ask why the Universe has chosen such a complicated way to hide its true nature, while not helping us with one single piece of experimental evidence.

In this connection, one should not forget that the weak gauge bosons $Z^0$ and $W^{+/−}$ have three (partly interrelated) ugly features compared to all other fundamental interactions, namely that they are very massive, highly unstable and contain electrically charged members. Only the former is logically explained by Higgs, while the other two are facts of life, and put in by hand in the electroweak theory.
2 Why take a preon?

In connection to the arguments given above, the most important virtue of preons (subquarks) is that they leave room for the $Z^0$ and $W^+/-$ to be composite. This was pointed out in most pioneering preon publications, although the actual composition varies from model to model (the bosons being composed of 2-6 preons).

The main arguments for a common substructure of quarks and leptons in terms of preons can therefore be listed:

- there are by now too many quarks and leptons to leave any particle physicist comfortable.

- there are regularities between quarks and leptons, suggesting a common origin (but still so many differences that preon modelling is a nontrivial challenge).

- most quarks and leptons are unstable, which in our view disqualifies them as fundamental particles, although this logical problem is rarely addressed in preon-free models for quarks, leptons and the three-family structure.

- preons can be used for building the weak vector bosons, and therefore predict that the weak force is not fundamental. It is just a "van der Waals" leakage of some multi-preon states, in almost exact analogy to the nuclear force being an exchange of mostly spin-1 mesons, i.e., quark-antiquark states. The celebrated relation between the $Z^0$ mass and the Weinberg angle has to do with preon couplings and masses, and not with electroweak unification [1].

3 Preon models in general

The existing preon models are often minimal in some respect:

- there can be a minimal number of different preons, namely two. The prime example is the so-called rishon model by Harari and others [2, 3], with two spin-1/2 rishons ($T$ and $V$), but with three rishons in each (light) quark and lepton. The vector bosons (and even the photon) are composite six-preon states.

- there can be a minimal number of preons inside a quark or lepton, namely two. Obviously, there must be preons with both spin 1/2 and 0
in such models. The prime example here is the so-called haplon model by Fritzsch and Mandelbaum [4]. Typically, one now uses four different preons (called $\alpha$, $\beta$, $x$ and $y$ in [4]) to build the light family of quarks and leptons.

There are some very clear problems with all such preon models. First, they do not explain why quarks and leptons seemingly belong to three families. The two heavier families are normally assumed to be some kind of "excitations" of the light one. Here one can think of internal radial excitations, or an extra preon-antipreon pair added to a light quark or lepton. There are even suggestions that completely different preon states exist inside one and the same family (e.g., that the $u$ and $d$ quarks have unequal preon numbers, or that quarks and leptons are completely different). In all such models it is hard to understand why three different lepton numbers are conserved (while quark numbers are not).

Secondly, the (almost?) massless neutrinos are not well understood, especially not in the heavier families. It is a paradox that preons in (maybe) the TeV mass range can form light neutrinos. No preon model (including ours) has been able to escape this problem.

In the literature there are several models where the authors try to join supersymmetry with preons. This is quite natural if there is supersymmetry in Nature, since any fundamental symmetry must have its origin on the truly fundamental particle level.

Since SUSY is essentially a symmetry between spin-1/2 and spin-0 particles it is most conveniently introduced in models of the haplon type. A first observation is then that the truly supersymmetric partner of a quark or lepton, consisting of one preon of each kind, is again a quark and a lepton. Hence, a SUSY preon model needs no "squarks" and "sleptons". SUSY is instead fully implemented by "preons and spreons", which are not observable on their own. One can naturally think of "pseudo-SUSY partners", where only one preon is substituted by a "spreon", but there is no reason why such states must exist. Exceptions are the heavy vector bosons, which in the haplon model would turn into normal leptons, if one of their spin-1/2 preons is substituted by a spin-0 spreon. Hence, the "zino" is a neutrino, and the "winos" are electrons and positrons!

It is quite impressive that a carefully selected preon model can eliminate the need of both the Higgs and all suggested SUSY particles (except the photino and the gluino).

The current literature on preon SUSY seems to originate from a paper by Pati and Salam [5], where it is suggested that all matter is built from two exactly supersymmetric, massless fields. Since these cannot be used for
directly building quarks and leptons, one has to assume that they are "pre-
preons". Several Japanese authors have tried to build more conventional
preons (with broken or no SUSY) out of these two fundamental fields (see
[6] for a recent example), and the result is very similar to the haplon model
[4]. As to the best of our knowledge, no efforts have been made to implement
SUSY (broken or not) directly on the preon level.

4 Our preons

The essence of our new preon model is that we introduce "extra" preons
in order to construct all three families of quarks and leptons, while still
maintaining as much symmetry and simplicity as possible in the full preon
scheme.

We start from the haplon idea of Fritzsch and Mandelbaum [4] that pre-
ons are spin-0 and spin-1/2 objects. However, it is crucial for our model that
the lightest family can, in fact, be built by three preons, i.e., one preon less
than in the haplon model. We also guess that there is some pairwise super-
symmetric relation between preons, i.e., as far as charges and the construc-
tion of composite states are concerned. This preon SUSY must, however,
be broken in the sense that the preon masses cannot be pairwise identical.

We then use as many preon pairs as needed to build the full three
quark/lepton families, and end up with three spin-0 "spreons" and three
spin-1/2 preons:

\[
\begin{array}{cccc}
Charge & +e/3 & -2e/3 & +e/3 \\
S = 0 & x & y & z \\
S = 1/2 & \alpha & \beta & \delta \\
\end{array}
\]

This is not a unique solution, but one of two alternatives for constructing
the lightest quark/lepton family with the three preons \( \alpha \), \( \beta \) and \( x \). The
other option has charges \(-e/6, +5e/6, -e/6\), which we, however, consider
less attractive than the ones chosen. Observe that our preons \( \alpha \), \( \beta \), \( x \) and
\( y \) are not identical to those in [4], although we use the same symbols. We
assume that all preons carry QCD colour, i.e., we do not adopt the idea in
[4] that only one preon has colour, and therefore exists only in quarks.

There are several arguments, to be discussed later in some detail, that
lead to the conclusion that either \( z \) or \( \delta \) is "superheavy", while the other is
just "heavy". A simple one is that only five preons are needed to explain
six quarks/leptons. So, another option would be to use only five preons, at
the expense of the simple symmetry in the scheme.

Before constructing the quarks and leptons we note that the spin-0 preons could themselves be "di-preons" of two spin-1/2 preons. The simplest (most symmetric) scheme, which also gives correct QCD colour charges, would then be:

\[ x = (\beta \delta), \quad y = (\bar{\alpha} \delta) \text{ and } z = (\bar{\alpha} \beta). \]

If so, our model would contain only spinor preons, and would therefore be closer in spirit to the "rishon" model [2, 3]. Supersymmetry then loses its meaning as a fundamental concept, but could still be of phenomenological relevance, like the "supersymmetry" between quarks and diquarks, quoted by diquark experts (see [7] for a review on diquarks). The tighter the di-preon binding, the more relevant is the "supersymmetry".

Strangely enough, the presence of a heavy δ gives light di-preons, while the light \( \bar{\alpha} \) and \( \bar{\beta} \) build up the heavy z. This resembles the idea promoted by some diquark workers, that diquark formation is relevant only when involving at least one heavy quark. If the (αβ) would, accordingly, be unbound we would again have only five objects (α, β, δ, x and y), i.e., the minimal number required for three families.

In the following, we will, for simplicity, keep the symbols x, y and z for the di-preons, until their internal composition needs to be discussed.

5 Building leptons, quarks and vector bosons

The preons fall into one triplet, \( 3_{1/2} \), of spin 1/2 and another one, \( 3_0 \), of spin 0. Keeping in mind that quarks carry QCD colour, while leptons and vector bosons are colour-neutral, we get:

- leptons = \( 3_{1/2} \times 3_0^* \) (or \( 3_{1/2}^* \times 3_0 \))
- quarks = \( 3_{1/2} \times 3_0 \)
- vector bosons = \( 3_{1/2} \times 3_{1/2}^* \)

where * signifies a triplet of antipreons. Hence, all three species will occur in nonets, with a possible split-up into one octet and one singlet, according to the \( SU(3) \) multiplication rule for two different triplets: \( 3_a \times 3_b = 8_{ab} + 1_{ab} \) (if \( a = b, \ 3 \times 3 = 6 + 3^* \)).

The similarity with the Eightfold Way for constructing hadrons with the lightest triplet of quarks (u, d and s) should not be exaggerated. Our \( SU(3)_{preon} \) symmetry is much more broken than the \( SU(3)_{uds} \), due to widely
different preon masses. And not even the $SU(3)_{uds}$ is very helpful for understanding all light hadron wave functions, in particular not the singlets. So we will not copy the theoretical $SU(3)$ eigenfunctions for quarks and leptons.

Nevertheless, the prediction of nonets is straightforward, and means that we predict the existence of several new particles, namely three new leptons, three new quarks and six new vector bosons - all presumably too massive to be seen by current experiments.

The nonets do not contain an underlying three-family substructure. Although a certain pattern can be seen, it has important deviations from the conventional one. The celebrated ”three families” are therefore merely the twelve lightest quarks and leptons that have been discovered so far.

6 The leptons

There are several, equally consistent, ways to build nine leptons out of three preon-spreon pairs. It seems to be mostly a matter of taste to identify a superheavy one ($\delta$ or $z$). We prefer to have a heavy $\delta$, because this will give a more consistent description of the three known charged leptons and their neutrinos. Each lepton pair then shares a common spreon, but different preons, which means that the decay of a charged lepton into its neutrino goes through an exchange of a preon-antipreon state, i.e., a composite $W$. A superheavy $z$ would, indirectly, require the $\tau$, but not the $\mu$, to decay through a break-up of a composite spreon, which would violate the well-known lepton universality.

It remains a certain ambiguity for the choice of the preon content of $(\mu, \nu_\mu)$ versus $(\tau, \nu_\tau)$. However, choosing a preon mass ordering where $\delta$ is the heaviest preon and $z$ the heaviest spreon, we pinpoint the $\tau$ and the $\nu_\tau$ as the ones containing the $z$. This hints at a mass relation like $m_\alpha, m_\beta, m_x < m_y < m_z \ll m_\delta$ (although no ordering is fully consistent).

The lepton scheme now reads:

$$\begin{align*}
\alpha \overline{e} &= \nu_e & \alpha \overline{\mu} &= \mu^+ & \alpha \overline{\tau} &= \nu_\tau \\
\beta \overline{e} &= e^- & \beta \overline{\mu} &= \mu^- & \beta \overline{\tau} &= \tau^- \\
\delta \overline{\nu_\kappa} &= \nu_\kappa & \delta \overline{\mu} &= \kappa^+ & \delta \overline{\tau} &= \nu_\kappa,2,
\end{align*}$$

where the bottom line contains the three new, superheavy leptons, two of which are somewhat arbitrarily classified as antineutrinos.

A number of observations can be made:
- all known lepton decays can be understood as reshuffling of preons into less massive states. The conservation of three lepton numbers \((L_e, L_\mu, L_\tau)\) among those decays is equivalent to \textit{preon stability}. These three lepton numbers are \textit{not} conserved in general.

- the decay of the hypothetical \(\kappa\) does \textit{not} conserve all lepton numbers, one example being \(\kappa^+ \rightarrow \nu_{\kappa 1} + \mu^- + \nu_e\).

- the scheme is not fully consistent, since the mass-ordering between some charged leptons and neutrinos does not follow the simple mass-ordering of preons as given above. It seems as if the low masses of neutrinos have to do both with their electric neutrality and with the preon masses.

- the non-observation of the three new leptons means that the superheavy \(\delta\) gives them a mass in the 50 GeV range or heavier. The two new neutrinos must naturally be heavier than half the \(Z^0\) mass. \textit{If} the \(z\) and \(x\) preons are stable, these two neutrinos should also be stable. Then they should mimic the hypothetical, superheavy neutralinos, \textit{e.g.}, in cosmic-ray detectors.

- consequently, the two massive neutrinos are candidates for dark matter, if they were produced in significant numbers at the Big Bang, and if they are stable. We can, however, exclude the possibility that they were produced on equal footing with the three light neutrinos, since a mass of only around 20 eV for one (stable) neutrino species would explain the bulk of galactic dark matter. There are three possible excuses why the Universe is not dominated by those superheavy neutrinos: (i) preons of different masses were not produced in equal numbers; (ii) the three spin-1/2 preons were produced in equal numbers, but they did not bind into equally many di-preons \((x, y\) and \(z)\); (iii) the superheavy neutrinos are not stable (see below).

- if the \(x, y\) and \(z\) are indeed di-preons, the most interesting modification of what is said above is that the three neutrinos \(\nu_e, \nu_\mu\) and \(\nu_{\kappa 2}\) have \textit{identical} preon contents, differing only in the grouping into di-preons: \(\nu_e = \alpha (\beta \delta)\), \(\nu_\mu = \beta (\alpha \delta)\) and \(\nu_{\kappa 2} = \delta (\alpha \beta)\) (no other leptons have mutually identical preon contents). This opens up for \(\nu_e \leftrightarrow \nu_\mu\) oscillations (if Nature can somehow make up for the apparent helicity difference). There can also be decays of the heavier neutrinos, in particular the superheavy ones, \textit{e.g.}, \(\nu_{\kappa 2} \rightarrow \tau^- + \nu_\tau + \mu^+\). Unless the two lightest neutrinos are massless, there should even exist \textit{electromagnetic decays}, like \(\tau^- \rightarrow \nu_e + \gamma\), which would be the preonic equivalent of the decay \(\Sigma^0 \rightarrow \Lambda^0 + \gamma\) in the quark world.

- the model therefore provides a way to understand the apparent lack of atmospheric muon-neutrinos, via either decays or oscillations among neutrinos. The recent evidence from the Los Alamos LSND collaboration of a \(\nu_\mu \rightarrow \nu_e\) transition can, however, be understood only if we have wrong
preon assignments for the ambiguous choice of \((\mu, \nu_\mu)\) versus \((\tau, \nu_\tau)\) (see above). If so, we would instead get a natural oscillation (or electromagnetic decay) between \(\nu_\tau\) and \(\nu_e\) and a possible small-scale oscillation between \(\nu_\mu\) and \(\nu_e\) due to a quantum-mechanical \(\alpha - \delta\) preon mixing. The latter will be discussed also in the next section.

7 The quarks

Building quarks with our preon scheme turns out to give several completely new possibilities, but also some new problems. The special features of quarks, in fact, require the spin-0 spreons to be di-preons. We therefore give the suggested assignments directly in terms of three-preon states with spin-1/2 preons only (noting that \(\beta \delta = \bar{\tau}, \alpha \delta = \bar{\nu}\) and \(\alpha \beta = \bar{\nu}\)):

\[
\begin{align*}
\alpha(\beta \delta) &= u & \alpha(\bar{\tau} \delta) &= s & \alpha(\bar{\nu} \bar{\beta}) &= c \\
\beta(\beta \delta) &= d & \beta(\alpha \delta) &= X & \beta(\alpha \bar{\beta}) &= b \\
\delta(\beta \delta) &= t & \delta(\bar{\tau} \delta) &= g & \delta(\bar{\nu} \bar{\beta}) &= h,
\end{align*}
\]

\(X, g, h\) being new quarks with charges \(-4e/3, -e/3, +2e/3\), respectively.

Several crucial observations can now be made:

- the three quarks in the bottom line are superheavy, due to the presence of the \(\delta\). This pinpoints the \(t\) as a superheavy quark, unrelated to the \(b\), and hence explains the enormous mass differences in the \(b-t\) ”family” and in the \(\tau-t\) ”pair”. These mass differences are, in fact, a problem in any composite model of quarks and leptons that relies on the conventional family structure.

- we predict the existence of two new superheavy quarks - the \(g\) ("gross") and the \(h\) ("heavy") - which are supposed to have masses not too far beyond the top mass.

- the predicted \(X\) quark is crucial for the model. Judging from its position in the scheme, it should, in some respect, lie between \(s\) and \(g\), and also between \(d\) and \(b\). One can, naturally, exclude that its mass falls between those of the \(d\) and \(b\) quarks. Taking into account that the lepton masses do not follow the preon scheme in a consistent way, this is at least not an isolated paradox. Maybe, the neutrinos are "too light" due to their lack of charge, while the \(X\) quark is "too heavy" due to its high charge. We expect, however, that "\(\delta\)-free" quarks and leptons are considerably lighter than the superheavy ones. This means that the \(X\) should be lighter than the \(t\). At first sight, this prediction seems controversial, but the experimental situation is, unfortunately, obscured by the fact that existing searches for new
quarks have been focused on finding a "fourth family", where the lightest member has been assumed to be a "b'" quark with charge $-e/3$ \cite{10}. For instance, a recent search \cite{11} for the b' relies on the assumption that the decay is dominated by the flavour-changing neutral-current process $b' \to b\gamma$, and the trigger system is set on energetic gammas. Our new $X$ quark would, most likely, decay through $X \to b + \mu^- + \nu_\mu$ (or $X \to b + \tau^- + \nu_\tau$), which means that one should look for fast muons correlated to $b$ quarks. There are similar decay channels to $s$ and $d$ quarks, and also purely hadronic ones, like $X \to s + \pi + d$ but these should be harder to find against the background.

A completely different idea is that the discovered "top quark" is indeed our $X$, \textit{i.e.}, that the "top" has charge $-4e/3$ and not $+2e/3$ as has been taken for granted. There seems to be no experimental hints as to the charge of the top, due to difficulties with estimating the net charge of a hadronic (quark) jet. In cases where, for instance, an outgoing positron has been detected, one does not know if the decaying quark was a top or an anti-top, since the correlated $b$ quark could equally well have been an $\bar{b}$ (from the decay of an $X$).

Finally, one can blame a non-observation of the $X$ on the well-known problem with "SU(3) singlets" in other models. In the original SU(3)$_{flavour}$ model of the $u$, $d$ and $s$ quarks, the masses and compositions of the baryon and meson singlets are not well understood.

- the fact that quarks, but apparently not leptons, mix with each other according to the Cabibbo-Kobayashi-Maskawa matrix can be understood in our model, but probably not in any other preon model where quarks and leptons are simply related. The important difference between quarks and leptons is that the former are composed of both preons and antipreons, giving access to preon-antipreon \textit{annihilation} channels between certain quarks. In particular, the $s = \alpha(\overline{\delta})$ and the $d = \beta(\overline{\delta})$ can mix via the process $\beta\beta \leftrightarrow \alpha\overline{\alpha}$, which can go through a composite $Z^0$, containing both $\beta\overline{\beta}$ and $\alpha\overline{\alpha}$, or via any other gauge boson (gluon, "hypergluon", photon?). The effect is weak, due to either the high $Z^0$ mass or a very strong di-preon binding, which suppresses the $\beta\overline{\beta}$ (and $\alpha\overline{\alpha}$) wave function overlaps. There are similar quark mixing channels between $c$ and $t$, and between $b$ and $g$.

- the smaller matrix elements, of order a per cent or less, in the CKM matrix cannot be understood with preon annihilation. Instead, a weak quantum-mechanical mixing of the $\alpha$ and $\delta$ preons is required. They differ only in mass, and could hence be mixed to some degree inside both quarks and leptons. This will give rise to a weak quark mixing between some quarks, which probably depends on quark masses and on the "location" of the rele-
vant preons (inside or outside the di-preons). It would also mix the $e^-$ and $\nu_e$ with the $\tau^-$ and $\nu_\tau$, or, alternatively, with the $\mu^-$ and $\nu_\mu$ for the alternative preon assignments of the heavy leptons, as discussed above. The latter might be consistent with the oscillation $\nu_\mu \rightarrow \nu_e$ claimed in [9], although we would expect it to have a magnitude well below the per cent level, which is on the lower side of the experimental error bars.

- it is still an open question if also CP violation can be explained by any of these quark peculiarities. An interesting observation is that the $K^0$ and $\bar{K}^0$ have identical preon contents, although arranged in different preon/di-preon configurations. This is no longer true if we introduce a small $\alpha - \delta$ mixing, which results in a $d - b$ quark mixing inside the kaons. If this preon mixing also involves a quantum-mechanical phase, it should result in a CP violation in the $K^0$ system. At least, the magnitude of the $d - b$ quark mixing is about the same as that of the CP violation (and, possibly, as that of the neutrino oscillation claimed by the LSND collaboration). The $D^0$ and $B^0$ mesons do not have the same preon contents as their antiparticles, whatever that means for their CP symmetry.

8 The vector bosons

Vector bosons come about as bound states of a preon and an antipreon. The most likely configurations are:

$$ (\alpha \overline{\beta}) = W^+ \quad (\alpha \overline{\tau}) - (\beta \overline{\beta}) = Z^0 \quad (\beta \overline{\tau}) = W^-,$$

with two other, heavier and orthogonal, combinations ($Z'$ and $Z''$) of $(\alpha \overline{\tau})$, $(\beta \overline{\beta})$ and $(\delta \overline{\delta})$, being equivalent to the $\omega$ and $\phi$ mesons in the quark model. There would also be another two neutral states with the mixed combinations $(\alpha \overline{\delta})$ and $(\delta \overline{\alpha})$, as well as two charged states of $(\beta \overline{\delta})$ and $(\delta \overline{\beta})$, all resembling the four $K^*$ mesons in the quark model. There might, of course, be mixings among these states, especially as they are all heavy and unstable.

In any preon model with composite vector bosons one also expects scalar partners [11]. The fact that they have not been observed can be blamed either on high masses or on very weak couplings to quarks and leptons. The latter might seem more realistic since spin-0 systems are normally lighter than those with spin 1 (the deuteron being an important exception). The similarity with the mesons in the quark world, and the considerable mass difference between the $\pi$ and the $\rho$ mesons make us suspect that the missing scalars might be "superlight", and maybe even lie in the MeV mass range. It
could be worthwhile to study possible decay modes and look for evidence in existing experimental data. One possibility is that the normal scalar mesons are indeed hybrids of quark-antiquark and preon-antipreon states.

9 Conclusions

Our efforts to construct a minimal preon model for all known quarks and leptons have led us to a scheme with only three fundamental spin-1/2 preons, which prefer to form tightly bound, scalar, di-preons. Quarks and leptons are three-preon (preon/di-preon) states, giving three new, very heavy leptons and three new quarks, one of which has charge $-4e/3$ and could be lighter than (or identical to) the top quark.

The different preon contents of quarks and leptons explain the main mixings described by the CKM matrix, and leaves an opening for understanding CP violation in terms of preon mixing.

The model by itself implies (requires) the so-called standard model of the electroweak interaction, the Higgs mechanism, the three families, etc, to be more or less wrong.

Many problems remain to be solved. One is the classical paradox of light neutrinos (and light leptons in general). Another is our not fully consistent mass-ordering of preons. There is hence a long way to go before we understand preon dynamics and forces, quark/lepton wave functions and the role of normal QCD contra a hypothetical "hyper-QCD" with "hypergluons" that keeps quarks and leptons together. Maybe normal QCD is nothing but the "long-range" tail of the hyper-QCD that acts between preons, reaching out from the coloured quarks, but not from the leptons.

As long as preon models have not yet developed into something as complicated as the Higgs mechanism, we consider them worthy of continued contemplation and theoretical efforts, especially as there exist interesting predictions also for energy ranges that do not need new accelerators, or a new millenium.

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