Abstract. - It is proposed that each quark is composed of two prequarks, called primons. This composition generates a new hypercharge and a new kind of color called supercolor. Such quark composition explains the Kobayashi-Maskawa matrix elements in terms of selection rules based on the new hypercharge. It is also shown that there should exist three Higgs bosons involved in the generation of quark masses.

Introduction

In recent years there have been attempts to go beyond the standard model in particle physics. Going beyond the standard model means breaking up quarks and/or leptons. Since the mass of the electron is already too small for a particle with a very small radius which is smaller than 0.01 F, we can consider it as being an elementary particle. Thus, in this article we propose that leptons are elementary and that quarks are composite. Actually, quark composition is an old idea\(^{(1,2,3,4)}\). In order to distinguish the quark composition proposed in this work from other models of the literature we will name these prequarks with a different name. We call them primons, a word derived from the Latin word primus which means first. Some preliminary ideas on this subject have lately been published by the author\(^{(5,6,7,8)}\).

The Number of Quarks and Primons, and the Supercolors

Let us develop some preliminary ideas which will help us towards the understanding of quark composition. Since a baryon is composed of three quarks it is reasonable to consider that a quark is composed of two primons. The new interaction between them exists by means of the exchange of new bosons to be found.

In order to reproduce the spectrum of 6 quarks and their colors we need 4 primons in 3 supercolor states. Each color is formed by the two supercolors of two different primons that form a particular quark. Therefore, the symmetry group associated to the supercolor filed is SU(2). As to the electric charge, one has charge \((+5/6)e\) and any other one has charge \((-1/6)e\).

Taking into account the above considerations on colors and electric charges of quarks we have the following tables for primons (Tables 1, 2, and 3). According to Table 1 the maximum number of quarks is six. There should exist similar tables for the corresponding antiparticles.
Table 1. Generation of colors from supercolors

| superflavor | charge   |
|-------------|----------|
| $\alpha$    | blue     |
| $\beta$     | blue     |
| $\gamma$    | green    |

Table 2. Electric charges of primons

| superflavor | charge |
|-------------|--------|
| $p_1$       | $+\frac{5}{6}$ |
| $p_2$       | $-\frac{1}{6}$ |
| $p_3$       | $-\frac{1}{6}$ |
| $p_4$       | $-\frac{1}{6}$ |
Table 3. Composition of quark flavors

|   | p₁ | p₂ | p₃ | p₄ |
|---|----|----|----|----|
| p₁ | u  | c  | t  |    |
| p₂ | u  | d  | s  |    |
| p₃ | c  | d  | b  |    |
| p₄ | t  | s  | b  |    |

The New Hypercharge and the new SU(2)

In order to find the new hypercharge let us recall the relation between electric charge and baryon number in quarks. Quark charges \( \frac{2}{3} \) and \( -\frac{1}{3} \) are symmetric about \( \frac{1}{6} \) (Figure 1) and, since \( \frac{2}{3} - (-\frac{1}{3}) = 1 = 2 \times (\frac{1}{2}) \), we have

\[
Q = \frac{B}{2} \pm \frac{1}{2} \tag{1}
\]

because \( \frac{1}{6} = (\frac{1}{2}) \times (\frac{1}{3}) = B/2 \). Equation (1) is in line with the formula

\[
Q = I_3 + \frac{1}{2} (B + S + C + B^* + T) \tag{2}
\]

where \( I_3 \) is the isospin component of the isospin, \( B = 1/3 \) is the baryon number and \( S, C, B^*, T \) denote the quark numbers for the quarks \( s, c, b \) and \( t \), respectively. \( C \) and \( T \) are equal to 1 and \( S \) and \( B^* \) are equal to \(-1\). The above formula (Eq. (2)) can also be written as

\[
Q = I_3 + \frac{Y}{2} \tag{3}
\]

which is the Gell-Mann–Nishijima relation where \( Y \) is the strong hypercharge.

Since for primons each \( B = 1/6 \) Eq. (1) is not valid. Instead of it we should have

\[
Q = 2B \pm \frac{1}{2} \tag{4}
\]
because electric charges are symmetric about 1/3 (Figure 1) since 1/3 = 2 × 1/6 = 2B. This implies that for a system of primons

\[ Q = 2B + \frac{1}{2}(P_1 + P_2 + P_3 + P_4) \]  

(5)

where \( B \) is the total baryon number, and \( P_1 = 1, P_2 = P_3 = P_4 = -1 \). From this we note that we may divide primons into two distinct categories and we should search for a new quantum number to characterize such distinction. Therefore, we have

\[ \frac{2}{3} = 2 \times \left( \frac{1}{6} + \frac{1}{6} \right) + \frac{1}{2}(1 - 1) \text{ for } u, c, t \]

and

\[ -\frac{1}{3} = 2 \times \left( \frac{1}{6} + \frac{1}{6} \right) + \frac{1}{2}(-1 - 1) \text{ for } d, s, b. \]

Because quarks \( u \) and \( d \) have isospin equal to 1/2 and -1/2, respectively, we are forced to make \( I_3 = \pm 1/4 \) for primons \( p_1 \) and \( p_2 \). We will see in detail below how \( I_3 \) can be assigned to them. And we will be able then to find that the other primons also have \( I_3 = \pm 1/4 \).

Let us try to write a simple expression for the charge of primons like the one that is used for nucleons. Following the footsteps of the strong hypercharge we can try to make

\[ Q = I_3 + \frac{Y}{2} \]  

(6)

where \( Y \) is the new hypercharge and is given by

\[ Y = B + \Sigma \]  

(7)

where \( \Sigma \) is a new quantum number to be found. Thus the formula becomes

\[ Q = I_3 + \frac{1}{2}(B + \Sigma) \]  

(8)

which is quite similar to the Gell-Mann–Nishijima formula used for quarks

\[ Q = I_3 + \frac{1}{2}(B + S). \]

From now on instead of dealing with the new hypercharge \( Y = B + \Sigma \) we will deal directly with \( \Sigma \). As was discussed above we should try \( \Sigma_3 = +1 \) for \( p_1 \) and \( \Sigma_3 = -1 \) for \( p_2, p_3, p_4 \). Therefore,

\[ \frac{5}{6} = \frac{1}{4} + \frac{1}{2} \left( \frac{1}{6} + 1 \right) \text{ for } p_1 \]
and

\[-\frac{1}{6} = \frac{1}{4} + \frac{1}{2} \left( \frac{1}{6} - 1 \right) \]  
for \( p_2, p_3, p_4 \).

As we will shortly see \( p_2, p_3, p_4 \) can also have \( I_3 = -1/4 \). In this case we have

\[-\frac{1}{6} = -\frac{1}{4} + \frac{1}{2} \left( \frac{1}{6} + 0 \right) \]  
for \( p_2, p_3, p_4 \).

This means thus that \( \Sigma_3 \) can assume the values \(-1, 0, \) and \(+1\) and, thus, they can be considered as the projections of \( \Sigma = 1 \). Of course \( \Sigma_3 = 0 \) can also be the projection of \( \Sigma = 0 \). Putting all together in a table one has Table 4 below.

| \( p_i \) | \( I_3 \) | \( \Sigma_3 \) |
|---|---|---|
| \( p_1 \) | \(+\frac{1}{4}\) | \(+1\) |
| \( p_j \) (\( j = 2, 3, 4 \)) | \(+\frac{1}{4}\) | \(-1\) |
| \( -\frac{1}{4} \) | \(0\) |

Let us now find the values of \( \Sigma \) for quarks. The results are quite impressive because they are directly linked to the Kobayashi-Maskawa matrix and to the quark doublets

\[
\begin{pmatrix}
  u \\
  d
\end{pmatrix}, \begin{pmatrix}
  c \\
  s
\end{pmatrix}, \begin{pmatrix}
  t \\
  b
\end{pmatrix}
\]

As was seen above \( p_1 \) can only have \( I_3 = 1/4 \), and \( p_2, p_3, p_4 \) can have \( I_3 = \pm 1/4 \). In the case of the \( u \) quark \( p_1 \) has \( I_3 = 1/4 \) and \( p_2 \) has \( I_3 = 1/4 \) because the \( I_3 \) of the \( u \) quark is \( 1/2 \), and the total value of \( \Sigma_3 \) is \(+1 + (-1) = 0\). For the \( d \) quark \( p_2 \) has \( I_3 = -1/4 \) and \( p_3 \) has \( I_3 = -1/4 \) because the \( I_3 \) of the \( d \) quark is \(-1/2 \), and the total \( \Sigma_3 \) is thus \( 0 + 0 = 0 \). In the case of \( c \) and \( t \) quarks, since \( p_1 \) has \( I_3 = 1/4 \), \( p_2 \) and \( p_3 \) should have \( I_3 = -1/4 \) because the \( I_3 \) of both quarks is equal to \( 0 \). In both cases the total \( \Sigma_3 \) is equal to \( +1 \). For quarks \( s \) and \( b \), their primons have to have opposite \( I_3 \)'s because the \( I_3 \) of both of them is equal to \( 0 \). And thus in both cases the total \( \Sigma_3 \) is equal to \(-1 \). Hence a system of two primons (that is, a quark) has four possible states \( |\Sigma, \Sigma_3>\):
The choice $|1, 0 > = d$, $|0, 0 > = u$ was made considering that the $u$ quark is the end product of the decays of quarks which means that it should be singled out. Making a table with the results we obtain Table 5

| $I_3$ | $\Sigma_3$ |
|-------|-------------|
| $c, t$ | 0 | +1 |
| $u$ | $+\frac{1}{2}$ | 0 |
| $d$ | $-\frac{1}{2}$ | 0 |
| $s, b$ | 0 | -1 |

Making a diagram with this table we obtain Figure 2

\[
\begin{pmatrix}
|0, 0 > \\
|1, 0 > \\
|1, 1 > \\
|1, -1 > \\
\end{pmatrix}, \begin{pmatrix}
|1, 1 > \\
|1, -1 > \\
\end{pmatrix}, \begin{pmatrix}
|1, 1 > \\
|1, -1 > \\
\end{pmatrix}
\]

which should be compared to

\[
\begin{pmatrix}
u \\
d\end{pmatrix}, \begin{pmatrix}c \\
s\end{pmatrix}, \begin{pmatrix}t \\
b\end{pmatrix}
\]

Comparing Figure 2 (or Table 5) with the Kobayashi-Maskawa matrix\footnote{9,10} we note that the elements of the matrix $|U_{ts}|$ and $|U_{tb}|$ (which are the largest ones are almost equal to 1) satisfy the selection rule $\Delta \Sigma_3 = -2$, $\Sigma = 0$, and the other large element $|U_{ud}|$ (which is also close to 1) satisfies the selection rule, $\Delta \Sigma = -1$, $\Sigma_3 = 0$. The second largest elements $|U_{cd}|$ ($= 0.24$) and $|U_{us}|$ ($= 0.23$) obey, respectively, the selection rules $\Delta \Sigma_3 = -1$, and $\Delta \Sigma_3 = +1$, $\Delta \Sigma = -1$. The null elements (or almost null) $|U_{ts}|$ and $|U_{cb}|$ can also be understood according to the above scheme if we also take into account the three quark doublets. According to the scheme flavor changing neutral currents are
forbidden because in such a case $\Delta \Sigma_3 = 0$. Taking a glance at the above diagram we can understand why $|U_{cs}| \approx |U_{tb}|$ and why $|U_{td}| \approx |U_{ub}|$. Another very important conclusion is that the $c$ and $t$ quarks are heavier versions of the $s$ and $b$ quarks, respectively. Thus, we can say that the general rule behind the weak decay of quarks is: a quark decays to diminish either its $\Sigma$ or its $\Sigma_3$. When $\Sigma = 1$ one way is to go from $\Sigma_3 = +1$ to $\Sigma_3 = -1$, 0, and another way is to go from $\Sigma_3 = -1$ to $\Sigma_3 = 0$ (but between $\Sigma = 1$ and $\Sigma = 0$), and when $\Sigma_3 = 0$ the only way left is to go from $\Sigma = 1$ to $\Sigma = 0$. If we represent the values of $\Sigma_3$ by arrows as we do with spin we find a complete similarity with the case of $S = 1$ for two 1/2 spin particles or with $I = 1$)(isospin) of the nucleon-nucleon system. That is,

$$
c = p_1 \uparrow p_3 \uparrow; \ t = p_1 \uparrow p_4 \uparrow; \ |1, 1 >
$$

$$
d = \frac{1}{\sqrt{2}} (p_2 \uparrow p_3 \downarrow + p_2 \downarrow p_3 \uparrow); \ |1, 0 >
$$

$$
s = p_2 \downarrow p_4 \downarrow; \ b = p_3 \downarrow p_4 \downarrow; \ |1, -1 >
$$

and

$$
u = \frac{1}{\sqrt{2}} (p_1 \uparrow p_2 \downarrow - p_1 \downarrow p_2 \uparrow); \ |0, 0 >
$$

and thus there is an $SU(2)$ related to $\Sigma$. This means that the variation of $\Sigma$ should be related to the variation of weak isospin. One clearly notices that both $t$ and $c$ have $p_1$, and thus, the mass difference between them is directly linked to how $p_3$ and $p_4$ interact with $p_1$ because $t$ and $c$ have the same $\Sigma$ and the same $\Sigma_3$. The same happens between quarks $s$ and $b$ which have $p_4$ in common. Since a given prion takes part in heavy and in light quarks as well ($p_1$, for example), prions probably have the same mass which should be a light mass. More on this we will see below. Another important point to consider is that by means of $\Sigma$ and $\Sigma_3$ we can understand why there are quark weak decays that conserve strong isospin ($t \rightarrow b$, $c \rightarrow s$).

This new $SU(2)$ is in complete agreement with weak isospin and, thus the Weinberg-Salam model (applied to quarks) does not need any deep modification since the symmetry continues to be the same. But by means of the new $SU(2)$ we can begin to understand what is behind the Kobayashi-Maskawa matrix: the composition of quarks.

Towards a New Chromodynamics (Superchromodynamics(SQCD))

As we saw in the sections above we need four primons and three supercolors to generate quarks in the three colors. This means that in terms of flavors primons can be represented by the Dirac spinors

$$
\Psi_1 = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \ \Psi_2 = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}, \ \Psi_3 = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}, \ \Psi_4 = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}.
$$
As to supercolors we may represent them by the three-element columns
\[ sc_\alpha = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \quad sc_\beta = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \quad sc_\gamma = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}. \]

The supercolor generators are the three-dimensional generators of SU(2)
\[ \Theta_1 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & i \\ 0 & -i & 0 \end{pmatrix}, \quad \Theta_2 = \begin{pmatrix} 0 & 0 & i \\ 0 & 0 & 0 \\ i & 0 & 0 \end{pmatrix}, \quad \Theta_3 = \begin{pmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \]
which are three of the eight generators of SU(3), and obey the relations
\[ [\Theta_j, \Theta_k] = i\varepsilon^{jkl} \Theta_l. \tag{9} \]

Let us call them supergluons. Such as gluons supergluons are vectorial \((S = 1)\) and also massless. According to the ideas above developed the combinations of equal supercolors do not produce a color. That is exactly what we have:
\[ sc_\alpha^\dagger \Theta^j sc_\alpha = sc_\beta^\dagger \Theta^j sc_\beta = sc_\gamma^\dagger \Theta^j sc_\gamma = 0, \]
where \(j = 1, 2, 3\). With different supercolors we have the sums:
\[ 3 \sum_{j=1}^3 sc_\alpha^\dagger \Theta^j sc_\beta = -i, \quad 3 \sum_{j=1}^3 sc_\alpha^\dagger \Theta^j sc_\gamma = i, \quad 3 \sum_{j=1}^3 sc_\beta^\dagger \Theta^j sc_\gamma = -i. \]

Therefore, the substructure of SU(3)(color) is SU(2)(supercolor). The Lagrangian of Quantum Superchromodynamics

Following the footsteps of QCD we can propose that the free Lagrangian for primons is
\[ L = i\hbar c \bar{\Psi} \gamma^\mu \partial_\mu \Psi - mc^2 \bar{\Psi} \Psi \tag{10} \]
in which \(\Psi\) is the column
\[ \Psi = \begin{pmatrix} \Psi_\alpha \\ \Psi_\beta \\ \Psi_\gamma \end{pmatrix}. \tag{11} \]
and \(\Psi_i\) is a four-component Dirac spinor. In the same way as is done in QCD we can construct the gauge invariant (under supercolor SU(2)) QSCD Lagrangian
\[ L = i\hbar c \bar{\Psi} \gamma^\mu \partial_\mu \Psi - mc^2 \bar{\Psi} \Psi - \frac{1}{16\pi} \Gamma^{\mu\nu} \Gamma_{\mu\nu} - g_{sc} \bar{\Psi} \gamma^\mu \Theta \Psi A_\mu \tag{12} \]
in which $g_{sc}$ is the supercolor coupling constant, and $\Gamma^{\mu\nu}$ are the supergluon fields. The above Lagrangian should hold for each primon because there are four different mass terms. That is, there are four different Lagrangians.

Since primons are almost massless the Lagrangian (for each primon) can be written as

$$L = i\hbar c \bar{\Psi} \gamma^\mu \partial_\mu \Psi - \frac{1}{16\pi} \Sigma^{\mu\nu} \Sigma_{\mu\nu} - g_{sc} \bar{\Psi} \gamma^\mu \Theta \Psi A_\mu.$$  \hspace{1cm} (13)

The last two Lagrangians above are invariant under local SU(2) gauge transformations and describe the interaction of each primon (that is, each flavor) with the three massless vector fields (supergluons). The Dirac fields make the three supercolor currents

$$I^\zeta = cg_{sc} \bar{\Psi} \gamma^\zeta \Theta \Psi \hspace{1cm} (14)$$

which are the sources of the supercolor fields.

The Masses of Primons

The magnetic moments of primons should be given by

$$\mu_1 = \frac{5}{6} \frac{e}{m_1} \text{ for } p_1$$
$$\mu_2 = -\frac{1}{6} \frac{e}{2m_2} \text{ for } p_2, p_3, p_4$$

and hence

$$\mu_2 = -\frac{5m_2}{m_1} \mu_1$$

and

$$\mu_3 = \frac{m_2}{m_3} \mu_2.$$  

Considering that the spin content of quarks should be the same we have

$$\frac{\mu_u}{\mu_d} = \frac{\mu_1 + \mu_2}{\mu_2 + \mu_3}$$

and since $\mu_u/\mu_d = -2$ and using the above relations we obtain

$$-2 = -\frac{5m_2}{m_1} \left( \frac{1 - \frac{m_2}{m_3}}{1 + \frac{m_2}{m_3}} \right).$$

Making $m_3 = fm_2$ and solving for the ratio $m_1/m_2$ we arrive at

$$\frac{m_1}{m_2} = \frac{5}{3 + \frac{2}{f}}$$

and since the mass of $u(p_1p_2)$ and $d(p_2p_3)$ are about the same it is reasonable to suppose that $m_3 \approx m_1$ and thus

$$f \approx \frac{5}{3 + \frac{2}{f}}$$
which yields \( f \approx 1 \) and hence \( m_3 \approx m_2 \). Then it is reasonable to assume that primons have about the same mass.

The Origin of Quark Mass

In order to have very light primons we can consider that every pair of primons of a quark are bound by means of a very strong spring. Thus the mass of each quark should be equal to

\[
m_q c^2 \approx \frac{\hbar \omega}{2} = \frac{\hbar}{2} \sqrt{\frac{k}{\mu_p}}
\]

in which \( \mu_p \) is the reduced mass of the pair of primons and \( k \) is the effective constant of the spring between them. It is worth mentioning that a quite similar idea is used for explaining quark confinement and based on it a term \( K r \) is introduced in the effective potential. For the u quark, for example, we have \( m_u c^2 \approx 0.3 \text{GeV} \). On the other hand if we consider a harmonic potential we have

\[
m_q c^2 \approx \frac{1}{2} k_u (R_q)^2
\]

where \( R_q \) is the size of the quark \( q \). For \( u \) we obtain \( k_u \approx 10^{20} \text{J/m}^2 \approx 2 \text{GeV}/\text{fm}^2 \). Using this figure above we obtain \( \mu_p \approx 10^{-28} \text{kg} \) which is about the proton mass. Therefore, in order to have light primons the effective well has to have a larger dependence with the distance between the two primons. Considering that the potential is symmetrical about the equilibrium position we may try to use the potential

\[
V(x) = \alpha u x^4.
\]

The energy levels of the potential \( V(x) = \alpha u x^\nu \) are given by

\[
E_n = \left[ \frac{\pi}{2 \nu} \frac{\nu!}{\nu!} \frac{4 \hbar \alpha u^{1/\nu}}{\Gamma \left( \frac{3}{2} + \frac{1}{\nu} \right)} \right]^{1/2} \left( n + \frac{1}{2} \right)^{2/\nu}.
\]

Thus, for \( \nu = 4 \) and \( n = 0 \) we have

\[
E_0 = \left[ \frac{\pi}{2 \mu_p} a u^{1/4} \frac{4 \hbar \alpha u^{1/4}}{\Gamma \left( \frac{3}{4} + \frac{1}{4} \right)} \right]^{4/3} \left( 0 + \frac{1}{2} \right)^{4/3}
\]

and then we obtain (making \( E_0 = m_q c^2 \))

\[
\mu_p \sim 0.25 \hbar^2 \sqrt{\frac{a_u}{(m_q c^2)^3}}
\]

which can be extremely light depending on the value of \( a_u \). The above figure should be taken with caution because it is a result of nonrelativistic quantum
mechanics but it does not change the fact that primons may have a very small mass. Thus, if primons interact via a very strong potential such as \( V(x) = \alpha u x^4 \) they can be extremely light fermions. We can then propose a more general effective potential of the form

\[
V(x) = \alpha u x^4 - \frac{1}{2} k u x^2
\]

where the last term is chosen negative. Generalizing the coordinate \( x \) we can consider the “potential energy”

\[
V_0(\phi) = \frac{1}{4} \lambda^2 \phi^4 - \frac{1}{2} \mu^2 \phi^2
\]

where \( \phi \) is a field related to the presence of the two primons (or of other primons of the same baryon) and is the scalar interaction between them, and \( \mu \) and \( \lambda \) are real constants. Hence we can propose the Lagrangian

\[
L_0 = \frac{1}{2} \left( \partial_\nu \phi \right) \left( \partial^\nu \phi \right) + \frac{1}{2} \mu^2 \phi^2 - \frac{1}{4} \lambda^2 \phi^4
\]

between the two primons of a quark. Since a quark only exists by means of the combination of the two primons we may consider that its initial mass is very small. The above Lagrangian is symmetric in \( \phi \) but let us recall that primons can interact by other means, electromagnetically, for example. Therefore, we can make the transformation \( \phi \rightarrow \phi + \eta_{ev} \) where \( \eta_{ev} \) is a deviation caused by the electromagnetic field and vacuum. The new potential energy up to second power in \( \eta_{ev} \) is

\[
V(\phi, \eta_{ev}) = V_0 - \mu^2 \phi \eta_{ev} - \frac{1}{2} \mu^2 \eta_{ev}^2 + \lambda^2 \phi^3 \eta_{ev} + \frac{3}{2} \lambda^2 \phi^2 \eta_{ev}^2
\]

\( V(\phi, \eta_{ev}) \) has a minimum at

\[
\eta_{ev}(\phi) = \frac{-\mu^2 \phi + \lambda^2 \phi^3}{\mu^2 - 3 \lambda^2 \phi^2}
\]

Since \( \eta_{ev} \) is small let us make \( \mu^2 \phi - \lambda^2 \phi^3 = \delta \) (a small quantity). Then we can make \( \phi \approx \pm \frac{\mu}{\lambda} + \epsilon \) and obtain \( \epsilon \approx -\frac{\delta}{2 \mu^2} \) and thus

\[
\phi \approx \pm \frac{\mu}{\lambda} - \frac{\delta}{2 \mu^2}
\]

and the symmetry has disappeared. But it is not spontaneously broken, it is broken by the perturbation \( \eta_{ev} \) which may be linked to charge. Substituting the above value of \( \phi \) into Eq 20 we have

\[
U(\eta_{ev}) = V(\phi, \eta_{ev}) - V_0 \approx \mu^2 \eta_{ev}^2
\]

and the approximate Lagrangian is

\[
\mathcal{L} = \frac{1}{2} \left( \partial_\nu \eta_{ev} \right) \left( \partial^\nu \eta_{ev} \right) - \mu^2 \eta_{ev}^2
\]
which is a Klein-Gordon Lagrangian with mass

\[ m = \sqrt{2} \mu \hbar / c \]  

which may be an effective mass. Taking a look at Table 3 we observe that we need three scalar bosons, \( \eta^e, \eta^\mu, \) and \( \eta^0 \). The first and second particles are exchanged between the primons of the quarks \( p_1 p_2(u), p_1 p_3(c), \) and \( p_1 p_4(t) \), and the neutral boson is exchanged between the primons of the quarks \( p_2 p_3(d), p_2 p_4(s), \) and \( p_3 p_4(b) \). Therefore, three Higgs bosons produce the masses of quarks.

It is quite interesting that we should have a triplet of scalar bosons. And we notice immediately a very important trend: The charged bosons produce masses larger than those produced by the neutral boson, considering the quark generations

\[
\begin{pmatrix}
  u \\
  d
\end{pmatrix}, \begin{pmatrix}
  c \\
  s
\end{pmatrix}, \begin{pmatrix}
  t \\
  b
\end{pmatrix}.
\]

Therefore, the origin of mass in quarks is also linked to the values of their charges.

This is summarized below in Table 6.
Table 6. The masses of quarks and their generators. As is known the mass of the $d$ quark is slightly larger than that of the $u$ quark. There is a clear division between the three first quarks and the other three quarks. The quarks generated by the charged bosons' have larger masses and larger charges and those generated by $\eta_{ev}^0$ have smaller masses and smaller charges.

The Arrangement of Primons in Baryons

A possible way for the arrangement of primons in baryons is discussed in references 5, 6, 7 and 8. Such arrangement agrees well with the electric charge distribution of the nucleons, with the nucleon dipole moments, with the stability of the alpha particle and of the deuteron, with the absence of nuclides with $A=5$, and with the enormous instability of $Be^8$.

The Spin of Primons (and Confinement)

The spin of primons is a great puzzle in the same way as the spin of a quark is too since as is well known only half of the spins of quarks contribute to the total spin of a baryon as found by the experiments. Actually, the spin puzzle of baryons may be linked to the spin of primons. Since they are elementary fermions we expect them to be half spin fermions. And thus it is not an easy
task to divise a way of making two spin half fermions to compose another spin half fermion since the space of spin is not the normal three-dimensional space. That is why the scheme divised in references 6 and 7 is not very good and may be wrong. When we make the addition of two different angular momenta we use the commutation relation

\[
\left[ \vec{S}_1, \vec{S}_2 \right] = 0
\]

which means that their degrees of freedom are independent. Maybe in the case of primons they are not independent since each set of primons is a baryon, that is, in the case of spin the problem to be solved is the problem of composing the total spin of a set of six particles subject to the rigid condition of obtaining a baryon in the end. This means that primons only exist forming baryons (and mesons) and thus free primons are not possible. Therefore, they are always confined.

This article intends to be just a preliminary work on quark composition. It appears to me that such composition is firmly established (indirectly) by the Kobaiaishi-Maskawa matrix. Much more work should be and will be developed on this subject.

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Figure 1
