Deducing Quark Rest Masses with Phenomenological Formulae

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Abstract

Using phenomenological formulae, we can deduce the rest masses and intrinsic quantum numbers (I, S, C, B and Q) of quarks, baryons and mesons from only one unflavored elementary quark family $\epsilon$. The deduced quantum numbers match experimental results exactly, and the deduced rest masses are 98.5% (97%) consistent with experimental results for baryons (or mesons). This paper predicts some quarks [$d_S(773)$, $d_S(1933)$ and $u_C(6073)$], baryons [$\Lambda_c(6599)$, $\Lambda_b(9959)$] and mesons [$D(6231)$, $B(9502)$]. PACS: 12.39.-x; 14.65.-q; 14.20.-c. Keywords: phenomenological, beyond the standard model.

I Introduction

One hundred years ago, classic physics had already been fully developed. Most physical phenomena could be explained with this physics. Black body spectrum, however, could not be explained by the physics of that time, leading Planck to propose a quantization postulate to solve this problem $\Box$. The Planck postulate eventually led to quantum mechanics. Physicists already clearly knew that the black body spectrum was a new phenomenon outside the applicable area of classic physics. The development from
classical physics to quantum physics depended mainly on new physical ideas rather than complex mathematics and extra dimensions of space.

Today we face a similar situation. The standard model [2] “is in excellent accord with almost all current data.... It has been enormously successful in predicting a wide range of phenomena,” but it cannot deduce the mass spectra of quarks. So far, no theory has been able to successfully do so. Like black body spectrum, the quark mass spectrum may need a new theory outside the standard model. M. K. Gaillard, P. D. Grannis, and F. J. Sciulli have already pointed out [2] that the standard model “is incomplete... We do not expect the standard model to be valid at arbitrarily short distances. However, its remarkable success strongly suggest that the standard model will remain an excellent approximation to nature at distance scales as small as $10^{-18}$m... high degree of arbitrariness suggests that a more fundamental theory underlies the standard model.” The history of quantum physics shows that a new physics theory’s primary need is new physical ideas. This paper gives new physical ideas using phenomenological formulae. Using these formulae, we try to deduce the rest masses of quarks.

\section{The Elementary Quarks and Their Free Excited States}

1). We assume that there is only one elementary quark family $\epsilon$ with $s = I = \frac{1}{2}$ and two isospin states ($\epsilon_u$ has $I^Z = \frac{1}{2}$ and $Q = +\frac{2}{3}$, $\epsilon_d$ has $I^Z = -\frac{1}{2}$ and $Q = -\frac{1}{3}$). For $\epsilon_u$ (or $\epsilon_d$), there are three colored (red, yellow or blue) quarks. Thus, there are six Fermi elementary quarks in the $\epsilon$ family with $S = C = B = 0$ in the vacuum. The elementary quarks $\epsilon_u$ and $\epsilon_d$ have the SU(2) symmetries.

2). As a colored elementary quark $\epsilon_u$ (or $\epsilon_d$) is excited from the vacuum, its color, electric charge, rest mass and spin do not change, but it will get energy. The excited
state of the elementary quark \( \epsilon_u \) is the u-quark with \( Q = \frac{2}{3} \), rest mass \( m_u^* \), \( I = s = \frac{1}{2} \) and \( I_Z = \frac{1}{2} \). The excited state of the elementary quark \( \epsilon_d \) is the d-quark with \( Q = -\frac{1}{3} \), rest mass \( m_d^* \), \( I = s = \frac{1}{2} \) and \( I_Z = -\frac{1}{2} \). Since \( \epsilon_u \) and \( \epsilon_d \) have the SU(2) symmetries, the free excited quarks \( u(m_u^*) \) and \( d(m_d^*) \) also have the SU(2) symmetries.

3). According to the Quark Model [3], a proton is composed of three quarks \([u(m_u^*)u(m_u^*)d(m_d^*)]\) and a neutron is also composed of three quarks \([u(m_u^*)u(m_d^*)d(m_d^*)]\). Thus proton mass \( M_p \) and neutron mass \( M_n \) are:

\[
M_p = m_u + m_u + m_d - |E_{\text{Bind}}(p)|, \\
M_n = m_u + m_d + m_d - |E_{\text{Bind}}(n)|, 
\]

where \( |E_{\text{Bind}}(p)| \) and \( |E_{\text{Bind}}(n)| \) are the strong binding energy of the three quarks inside \( p \) and \( n \). Omitting electromagnetic masses, we have

\[
M_p = M_n = 939 \text{ Mev}, \quad m_u^* = m_d^* \quad \text{and} \quad |E_{\text{Bind}}(p)| = |E_{\text{Bind}}(n)|. 
\]

\( |E_{\text{Bind}}(p)| = |E_{\text{Bind}}(n)| = |E_{\text{Bind}}| \) is a unknown complex function. As a phenomenological approximation, we assume that \( |E_{\text{Bind}}| = 3\Delta \). \( \Delta \) is an unknown large constant (\( \Delta >> m_p = 938 \text{ Mev} \)). From (1) and (2), we find \( m_u^* = m_d^* = 313 + \Delta \)

\[
u(313+\Delta) \quad \text{and} \quad d(313+\Delta) \\
\Delta = \frac{1}{3} |E_{\text{Bind}}| >> m_p = 938 \text{ Mev} 
\]

Remember that we have already found two long-lived quarks \( u(313+\Delta) \) and \( d(313+\Delta) \). They are the free excited states of \( \epsilon_u \) and \( \epsilon_d \). They compose the most important baryons \( p(939) \) (with \( I = \frac{1}{2}, \ I_z = \frac{1}{2}, \ Q = 1, \ S = C = B = 0 \)) and \( n(939) \) (with \( I = \frac{1}{2}, \ I_z = -\frac{1}{2}, \ Q = S = C = B = 0 \)) and mesons \( \pi \) (with \( I = 1, \ Q = +1, 0, -1, S = C = B = 0 \)).
III Phenomenological Formulae for Energy Bands

1). In order to deduce the short-lived quarks, we assume a phenomenological energy band formula. There are energy band excited states of the elementary quark $\epsilon$ whose energies are given by the following formula:

$$E(\mathbf{\kappa}, \mathbf{n}) = 313 + \Delta + 360 E(\mathbf{\kappa}, \mathbf{n})$$

$$E(\mathbf{\kappa}, \mathbf{n}) = [(n_1-\xi)^2+(n_2-\eta)^2+(n_3-\zeta)^2],$$

where $\mathbf{\kappa} = (\xi, \eta, \zeta)$. $(\xi, \eta, \zeta)$ are the coordinates of the symmetry axes of the regular rhombic dodecahedron in $\mathbf{\kappa}$-space as shown in Fig.1 and $\mathbf{n} = (n_1, n_2, n_3)$, $n_1$, $n_2$ and $n_3$ are $\pm$ integers or zero.

2). If we assume $n_1 = l_2 + l_3$, $n_2 = l_3 + l_1$ and $n_3 = l_1 + l_2$, so that

$$l_1 = \frac{1}{2}(-n_1 + n_2 + n_3)$$
$$l_2 = \frac{1}{2}(+n_1 - n_2 + n_3)$$
$$l_3 = \frac{1}{2}(+n_1 + n_2 - n_3).$$

$n_1$, $n_2$ and $n_3$ are those values of $\mathbf{n} = (n_1, n_2, n_3)$ that make $\mathbf{l} = (l_1, l_2, l_3)$ an integer vector ($l_1$, $l_2$, $l_3$ are $\pm$ integers or zero). For example, $\mathbf{n}$ cannot take the values $(1, 0, 0)$ or $(1, 1, -1)$, but can take $(0, 0, 2)$ and $(1, -1, 2)$. From $E(\mathbf{\kappa}, \mathbf{n})$, we can give a definition of the equivalent $\mathbf{n}$: for $\xi = \eta = \zeta = 0$, all $\mathbf{n}$ values that give the same $E(\mathbf{\kappa}, \mathbf{n})$ value are equivalent $n$-values. We show the low level equivalent $\mathbf{n}$-values that
satisfy condition (5) in the following list (note \( n_i = - n_i \)):

| \( E(0, \vec{n}) \) | Notes: \( \overrightarrow{T12} \equiv (-1, 1, 2) \) and \( \overrightarrow{T17} \equiv (-1, -1, 2) \) |
|-------------------|--------------------------------------------------|
| 0 : (0, 0, 0)     | Notes: \( \vec{n} = (-1, 1, 2) \) and \( \vec{n} = (-1, 1, -2) \) |
| 2 : (101, 010, 011, 101, 010, 011, 010, 011) | |
| 4 : (002, 000, 000, 000, 000, 000, 000, 000) | |
| 6 : (112, 211, 121, 211, 121, 121, 121, 121) | |
| 8 : (220, 222, 222, 222, 222, 222, 222, 222) | |

3). From Fig.1, we can see that there are four kinds of symmetry points (Γ, H, P and N) and six kinds of symmetry axes (Δ, Λ, Σ, D, F and G) in the regular rhombic dodecahedron. The coordinates \((\xi, \eta, \zeta)\) of the symmetry points are:

\[
\vec{r}_\Gamma = (0, 0, 0), \quad \vec{r}_H = (0, 0, 1), \quad \vec{r}_P = (\frac{1}{2}, \frac{1}{2}, \frac{1}{2}), \quad \vec{r}_N = (\frac{1}{2}, \frac{1}{2}, 0).
\]  

The coordinates \((\xi, \eta, \zeta)\) of the symmetry axes are:

\[
\vec{r}_\Delta = (0, 0, \zeta), \quad 0 \leq \zeta \leq 1; \quad \vec{r}_\Lambda = (\xi, \xi, \xi), \quad 0 \leq \xi \leq \frac{1}{2};
\]

\[
\vec{r}_\Sigma = (\xi, \xi, 0), \quad 0 \leq \xi \leq \frac{1}{2}; \quad \vec{r}_D = (\frac{1}{2}, \frac{1}{2}, \xi), \quad 0 \leq \xi \leq \frac{1}{2};
\]

\[
\vec{r}_G = (\xi, 1-\xi, 0), \quad \frac{1}{2} \leq \xi \leq 1; \quad \vec{r}_F = (\xi, \xi, 1-\xi), \quad 0 \leq \xi \leq \frac{1}{2}.
\]  

4). The energy (4) with an allowed \( \vec{n} = (n_1, n_2, n_3) \) in (6) along a symmetry axis \( \vec{r} = (\xi, \eta, \zeta) \) take the values in (8) forms an energy band. Each energy band corresponds to a short-lived quark.

5). After getting (4), (6), (7) and (8), we can deduce low energy bands of the six symmetry axes (see Appendix B of (4)). As an example, we will deduce the single energy bands of the Δ-axis in this paper. For the Δ-axis, \( \vec{r}_\Delta = (0, 0, \zeta) \) from (8). Putting \( \vec{r}_\Delta \) into (4), we get \( E(\vec{r}_\Delta, \vec{n}) = 313 + \Delta + 360[(n_1)^2 + (n_2)^2 + (n_3-\zeta)^2] \). For point-Γ, \( \vec{r}_\Gamma = (0, 0, 0) \) from (7), \( E_\Gamma(\vec{n}) = (n_1)^2 + (n_2)^2 + (n_3)^2 \). For point-H, \( \vec{r}_H = (0, 0, 1) \) from (7), \( E_H(\vec{n}) = (n_1)^2 + (n_2)^2 + (n_3-1)^2 \). Putting \( (n_1, n_2, n_3) \) values of the single bands of
the Δ-axis into \(E(\vec{\kappa}, \vec{n})_\Delta\), \(E_\Gamma(\vec{n})\) and \(E_H(\vec{n})\), we can find energy bands as shown in Table 1:

| \((n_1,n_2,n_3)\) | \(E(\vec{\kappa}, \vec{n})_{\text{Start}}\) | Minim.E | E-Band \(E(\vec{\kappa}, \vec{n})_\Delta\) | \(E(\vec{\kappa}, \vec{n})_{\text{end}}\) |
|-------------------|------------------|--------|-------------------------------|------------------|
| (0, 0, 0)         | \(E_\Gamma(0,0,0)= 0\) | 313+Δ  | 313+Δ+ζ²                      | \(E_H(0,0,0)=1\) |
| (0, 0, 2)         | \(E_H(0,0,2)= 1\)  | 673+Δ  | 313+Δ+(2-ζ)²                  | \(E_\Gamma(0,0,2)=4\) |
| (0, 0, -2)        | \(E_\Gamma(0,0,-2)=4\) | 1753+Δ | 313+Δ+(2+ζ)²                  | \(E_H(0,0,-2)=9\) |
| (0, 0, 4)         | \(E_H(0,0,4)= 9\)  | 3553+Δ | 313+Δ+(4-ζ)²                  | \(E_\Gamma(0,0,4)=16\) |
| (0, 0, -4)        | \(E_\Gamma(0,0,-4)=16\) | 6073+Δ | 313+Δ+(4+ζ)²                  | \(E_H(0,0,-4)=25\) |
| (0, 0, 6)         | \(E_H(0,0,6)=25\)  | 9313+Δ | 313+Δ+(6-ζ)²                  | \(E_\Gamma(0,0,6)=36\) |

\(E(\vec{\kappa}, \vec{n})_{\text{Start}}\) is the value of \(E(\vec{\kappa}, \vec{n})\) at the start point of the energy band.

\(E(\vec{\kappa}, \vec{n})_{\text{end}}\) is the value of \(E(\vec{\kappa}, \vec{n})\) at the end point of the energy band.

Similarly, we can deduce the single energy bands of the Σ-axis. For the Σ-axis, \(\vec{\kappa}_\Sigma= (\xi, \xi, 0)\). Putting the \(\vec{\kappa}_\Sigma\) into (4), we have \(E(\vec{\kappa}, \vec{n})_\Sigma = 313+\Delta + 360[(n_1-\xi)^2+(n_2-\xi)^2+(n_3)^2] 0 \leq \zeta \leq \frac{1}{2}\). For point-N, \(\vec{\kappa}_N = (\frac{1}{2}, \frac{1}{2}, 0)\) from (7), \(E_N(\vec{n}) = (n_1-\frac{1}{2})^2+(n_2-\frac{1}{2})^2+(n_3)^2\). Putting \((n_1,n_2,n_3)\) values of the single bands of the Σ-axis (Appendix B, Table B2 of [4]) into \(E(\vec{\kappa}, \vec{n})\), \(E_\Gamma(\vec{n})\) and \(E_N(\vec{n})\), we can deduce energy bands as shown in Table 2.
### IV Phenomenological Formulae for Rest Masses and Intrinsic Quantum Numbers

In order to deduce the short-lived quarks from the energy bands in Tables 1 and 2, we assume that each energy band corresponds to a quark and that the rest mass and intrinsic quantum numbers (I, S, C, B and Q) of the quarks can be deduced using the following phenomenological formulae from the energy bands:

1. For a group of degenerate energy bands (number = deg) with the same energy and equivalent $\vec{n}$ values $(6)$, the isospin of the corresponding excited quark is

\[
2I + 1 = \text{deg} \rightarrow I = \frac{\text{deg} - 1}{2}
\]  

2. The strange number $S$ of an excited quark that lies on an axis with a rotary fold $R$ of the regular rhombic dodecahedron is

\[
S = R - 4.
\]

3. For an energy band with deg < R and R - deg $\neq 2$, the strange number of the

| Energy Band $\mathbb{E}(\vec{r}, \vec{n})_{\Sigma}$ | $= 313 + \Delta + 360[(n_1-\xi)^2+(n_2-\xi)^2+(n_3)^2]$ | Energy Bands $\mathbb{E}(\vec{r}, \vec{n})_{\Sigma}$ |
|-----------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| $n_1n_2n_3$ | $E_{\Gamma}(0, 0, 0)=0$ | $= 313 + \Delta$ | $E_{\Gamma}(0, 0, 0)=\frac{1}{2}$ |
| $(1, 1, 0)$ | $E_{\Gamma}(0, 0, 0)=\frac{1}{2}$ | $493 + \Delta$ | $E_{\Gamma}(0, 0, 0)=2$ |
| $(-1, -1, 0)$ | $E_{\Gamma}(0, 0, 0)=2$ | $1033 + \Delta$ | $E_{\Gamma}(0, 0, 0)=\frac{9}{2}$ |
| $(2, 2, 0)$ | $E_{\Gamma}(0, 0, 0)=\frac{9}{2}$ | $1933 + \Delta$ | $E_{\Gamma}(0, 0, 0)=8$ |
| $(-2, -2, 0)$ | $E_{\Gamma}(0, 0, 0)=8$ | $3193 + \Delta$ | $E_{\Gamma}(0, 0, 0)=\frac{25}{2}$ |
| $(3, 3, 0)$ | $E_{\Gamma}(0, 0, 0)=\frac{25}{2}$ | $4813 + \Delta$ | $E_{\Gamma}(0, 0, 0)=18$ |
| $(-3, -3, 0)$ | $E_{\Gamma}(0, 0, 0)=18$ | $6793 + \Delta$ | $E_{\Gamma}(0, 0, 0)=\frac{49}{2}$ |
| $(4, 4, 0)$ | $E_{\Gamma}(0, 0, 0)=\frac{49}{2}$ | $9133 + \Delta$ | $E_{\Gamma}(0, 0, 0)=32$ |
corresponding quark is

\[
\text{deg}<R \text{ and } R-\text{deg} \neq 2, \quad S = S_{\text{axis}} + \Delta S, \\
\Delta S = \delta(\vec{n}) + [1-2\delta(S_{\text{axis}})]\text{Sign}(\vec{n})
\] (11)

where \(\delta(\vec{n})\) and \(\delta(S_{\text{axis}})\) are Dirac functions and \(S_{\text{axis}}\) is the strange number of the axis. For an energy band with \(\vec{n} = (n_1, n_2, n_3)\), \(\vec{n}\) is defined as

\[
\vec{n} \equiv \frac{n_1+n_2+n_3}{|n_1|+|n_2|+|n_3|}, \quad \text{Sign}(\vec{n}) = \\
\begin{cases} 
+1 & \text{for } \vec{n} > 0 \\
0 & \text{for } \vec{n} = 0 \\
-1 & \text{for } \vec{n} < 0
\end{cases}
\] (12)

If \(\vec{n} = 0\), \(\Delta S = \delta(0) = +1\) from (11) and (12). (13)

If \(\vec{n} = 0\), \(\Delta S = -S_{\text{Axis}}\). (14)

Thus, for \(\vec{n} = (0, 0, 0)\), from (14), we have

\[
S = S_{\text{Axis}} + \Delta S = S_{\text{Axis}} - S_{\text{Axis}} = 0.
\] (15)

4). If \(S = +1\), we call it the charmed number \(C (= 1)\):

if \(\Delta S = +1 \rightarrow S = S_{\text{Axis}} + \Delta S = +1, \quad C \equiv +1.\) (16)

If \(S = -1\), which originates from \(\Delta S = +1\) on a single energy band \((S_{\text{Axis}} = -2)\), and there is an energy fluctuation \((20)\), we call it the bottom number \(B\):

for single bands, if \(\Delta S = +1 \rightarrow S = -1\) and \(\Delta E \neq 0, \quad B \equiv -1.\) (17)
5). The elementary quark $\epsilon_u$ (or $\epsilon_d$) determines the electric charge $Q$ of an excited quark. For an excited quark of $\epsilon_u$ (or $\epsilon_d$), $Q = +\frac{2}{3}$ (or $-\frac{1}{3}$). For an excited quark with isospin $I$, there are $2I + 1$ members. $I_z > 0$, $Q = +\frac{2}{3}$; $I_z < 0$, $Q = -\frac{1}{3}$;

for $I_z = 0$, if $S+C+B > 0$, $Q = Q_{\epsilon_u(0)} = \frac{2}{3}$; 
for $I_z = 0$, if $S+C+B < 0$, $Q = Q_{\epsilon_d(0)} = -\frac{1}{3}$. (18)

There is no quark with $I_z = 0$ and $S+C+B = 0$.

6). Since the most experimental full widths of baryons and mesons are about 100 Mev, for simplicity, we assume that a fluctuation $\Delta E$ of a quark is

$$\Delta E = 100 S[(1+S_{Ax})(J_{S_{z}}+S_{Ax})]\Delta S \quad J_S = |S_{Ax}| + 1, 2, 3, \ldots$$

(20)

The rest mass ($m^*$) of a quark is the minimum energy of the band. From (4) and (20), the rest mass is

$$m^* = \{313 + 360 \text{ Minimum}[(n_1-\xi)^2+(n_2-\eta)^2+(n_3-\zeta)^2] + \Delta E + \Delta\} \text{ (Mev)}$$

$$= m + \Delta \text{ (Mev),}$$

(21)

This formula (21) is the united quark mass formula.

V \hspace{1cm} \text{Deducing Quarks from Energy Bands}

From deduced energy bands in Table 1, we can use the above phenomenological formulae (9)-(21) to deduce quarks. For the $\Delta$-axis, $R = 4$, $S_{axis} = 0$ from (10). For single energy bands, $I = 0$ from (9); and $S = S_{axis} + \Delta S = \Delta S = \delta(\tilde{n}) + [1-2\delta(S_{axis})]Sign(\tilde{n})$ from (11). For $\tilde{n} = (0, 0, -2)$ and $(0, 0, -4)$, $\Delta S = +1$ from (12) and (11); for $n = (0, 0, 2)$, (0, 0, 4) and (0, 0, 6) $\Delta S = -1$ from (12) and (11). Using (16), (12) and (11), we can find the charmed number $C = +1$ when $n = (0, 0, -2)$ and (0, 0, -4). From (13), we can find $Q = \frac{2}{3}$ when $n = (0, 0, -2)$ and (0, 0, -4); from (19), $Q = -\frac{1}{3}$ when $n = (0,$
0, 2), (0, 0, 4) and (0, 0, 6). From (20) and (21), we can find the rest masses (minimE + ∆E). Same flavored quarks with red, yellow or blue colors have the same rest masses and intrinsic quantum numbers, so we can omit their colors. We list all results in Table 3:

Table 3. The uC(m*)-quarks and the dS(m*)-quarks on the Δ-axis

| S_axis = 0, I = 0, S = ∆S = δ(\tilde{n}) + [1-2δ(S_axis)]Sign(\tilde{n}), \tilde{n} \equiv \frac{\nu_1+\nu_2+\nu_3}{|\nu_1|+|\nu_2|+|\nu_3|} | n_1, n_2, n_3 | E_{Point} | Min. E | ∆S | J | I | S | C | Q | ∆E | qName(m*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0, 0, 0 | E_r=0 | 313 | 0 | J_r=0 | \frac{1}{2} | 0 | 0 | \frac{2}{3} | 0 | u(313+Δ) |
| 0, 0, 2 | E_H=1 | 673 | -1 | J_H=1 | 0 | -1 | 0 | -\frac{1}{3} | 100 | d_S(773+Δ) |
| 0, 0, -2 | E_r=4 | 1753 | +1 | J_r=1 | 0 | 0 | 1 | \frac{2}{3} | 0 | u_C(1753+Δ) |
| 0, 0, 4 | E_H=9 | 3553 | -1 | J_H=2 | 0 | -1 | 0 | -\frac{1}{3} | 200 | d_S(3753+Δ) |
| 0, 0, -4 | E_r=16 | 6073 | +1 | J_r=2 | 0 | 0 | 1 | \frac{2}{3} | 0 | u_C(6073+Δ) |
| 0, 0, 6 | E_H=25 | 9313 | -1 | J_H=3 | 0 | -1 | 0 | -\frac{1}{3} | 300 | d_S(9613+Δ) |

Similarly, for the Σ-axis, S_axis = -2 from (10). For single energy bands, I = 0 from (9). From (11), S = S_axis + ∆S = -2 + ∆S; the ∆S = δ(\tilde{n}) + [1-2δ(S_axis)]Sign(\tilde{n}). For \tilde{n} = (1, 1, 0), (2, 2, 0), (3, 3, 0) and (4, 4, 0), ∆S = +1 from (12) and (11); for \tilde{n} = (-1, -1, 0), (-2, -2, 0) and (-3, -3, 0), ∆S = -1 from (12) and (11). Using (17), (12), (11) and (20), we can find the bottom number B = -1 when \tilde{n} = (3, 3, 0) and (4, 4, 0). From (18) and (19), we can find the electric charge Q = -\frac{1}{3} for all quarks. From (20) and (21), we can deduce rest masses (Min. E + ∆E) of quarks from the energy bands in Table 2. Same flavored quarks with red, yellow or blue colors have the same rest masses and intrinsic quantum numbers, so we omit their colors. We list all results in Table 4:
Table 4. The $d_b(m^*)$, $d_S(m^*)$ and $d_\Omega(m^*)$ Quarks of the $\Sigma$-Axis

| $S_{axis} = -2, I = 0, S = S_{axis} + \Delta S = \delta(\vec{n}) + [1 - 2\delta(S_{axis})] \text{Sign}(\vec{n})$, $\vec{n} \equiv \frac{n_1 + n_2 + n_3}{|n_1| + |n_2| + |n_3|} | E_{Point} | n_1,n_2,n_3 | \Delta S | S | B | Q | J | I | E_{Min.} | \Delta E | d_{Name}(m^*) |
|---|---|---|---|---|---|---|---|---|---|---|
| $E_\Gamma = 0$ | (0, 0, 0) | +2# | 0 | 0 | $-\frac{1}{3}$ | $J_\Gamma = 0$ | $\frac{1}{2}$ | 313 | 0 | $d(313+\Delta)$ |
| $E_N = \frac{1}{2}$ | (1, 1, 0) | -1 | -1 | 0 | $-\frac{1}{3}$ | $J_N = 1$ | 0 | 493 | 0 | $d_S(493+\Delta)$ |
| $E_\Gamma = 2$ | (-1, -1, 0) | -1 | -3 | 0 | $-\frac{1}{3}$ | $J_\Gamma = 1$ | 0 | 1033 | 0 | $d_\Omega(1033+\Delta)$ |
| $E_N = \frac{9}{2}$ | (2, 2, 0) | +1 | -1 | 0 | $-\frac{1}{3}$ | $J_N = 2$ | 0 | 1933 | 0 | $d_S(1933+\Delta)$ |
| $E_\Gamma = 8$ | (-2, -2, 0) | -1 | -3 | 0 | $-\frac{1}{3}$ | $J_\Gamma = 2$ | 0 | 3193 | 0 | $d_\Omega(3193+\Delta)$ |
| $E_N = \frac{25}{2}$ | (3, 3, 0) | +1 | 0 | -1 | $-\frac{1}{3}$ | $J_N = 3$ | 0 | 4813 | 100 | $d_b(4813+\Delta)$ |
| $E_\Gamma = 18$ | (-3, -3, 0) | -1 | -3 | 0 | $-\frac{1}{3}$ | $J_\Gamma = 3$ | 0 | 6793 | -300 | $d_\Omega(6493+\Delta)$ |
| $E_N = \frac{49}{2}$ | (4, 4, 0) | +1 | 0 | -1 | $-\frac{1}{3}$ | $J_N = 4$ | 0 | 9133 | 200 | $d_b(9333+\Delta)$ |

For $(n_1, n_2, n_3) = (0, 0, 0)$, $\Delta S = - S_{axis} = +2$ from [14]

From Tables 3 and 4, we can find that: The unflavored ground quarks are $u(313+\Delta)$ and $d(313+\Delta)$. The strange quarks $d_s(493)$, $d_s(773)$, $d_s(1933)$, $d_s(3753)$, $d_s(9613)$, $d_\Omega(1033+\Delta)$, $d_\Omega(3193+\Delta)$, and $d_\Omega(6493+\Delta)$; the strange ground quark is $d_s(493)$. The charmed quarks $u_c(1753)$ and $u_c(6073)$; the charmed ground quark is $u_c(1753)$. The bottom quarks $d_b(4913)$ and $d_b(9333)$; the bottom ground quark is $d_b(4913)$. (in Table 11 of [4] we have shown all low energy quarks, the five deduced ground quarks are still the ground quarks of all quarks). The five ground quarks correspond to the five quarks of the current Quark Model. The deduced intrinsic quantum numbers $(I, S, C, B$ and $Q)$ of the five ground quarks are exactly the same as the five current quarks as shown in Table 5A:

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Table 5A. The Five Deduced Ground Quarks and Current Quarks

| Quark(m$^s$) | u(313), u | d(313), d | d$_s$(493), s | u$_c$(1753), c | d$_b$(4913), B |
|-------------|------------|------------|----------------|---------------|----------------|
| Strange S   | 0          | 0          | 0              | 0             | 0              |
| Charmed C   | 0          | 0          | 0              | 0             | 1              |
| Bottom B    | 0          | 0          | 0              | 0             | 0              |
| Isospin I   | 1/2        | 1/2        | 1/2            | 0             | 0              |
| I$_Z$       | 1/2        | 1/2        | -1/2           | 0             | 0              |
| Electric Q$_q$ | 2/3       | 2/3        | -1/3           | 1/3           | 1/3            |

$^s$ The rest mass of a quark m$^*$ = m + $\Delta$ → m = m$^*$ - $\Delta$

The deduced rest masses of the five ground quarks are roughly a constant (about 390 Mev) larger than the masses of the current quarks, as shown in Table 5B.

Table 5B Comparing the Rest Masses of Deduced and Current Quarks

| Quark       | Up    | Down | Strange | Charmed | bottom |
|-------------|-------|------|---------|---------|--------|
| Current Quark(m) | u(2.8) | d(6) | s(105)  | c(1225) | b(4500) |
| Current quark mass | 1.5 to 4 | 4 to 8 | 80 to 130 | 1250 to 1350 | 4.1 to 4.4 G. |
|                |       |      |         |         | 4.6 to 4.9 G. |
| Deduced Quark (mass) | u(313) | d(313) | d$_s$(493) | u(1753) | d$_b$(4913) |
| | 310   | 307  | 388    | 528    | 413    |

These mass differences may originate from different energy reference systems. If we use the same energy reference system, the deduced masses of ground quarks will be roughly consistent with the masses of the corresponding current quarks. Of course, the ultimate test is whether or not the rest masses of the baryons and mesons composed of the deduced quarks are consistent with experimental results.

We will deduce the baryons and mesons composed of the quarks in Tables 3 and 4.
VI The Baryons of the Quarks in Tables 3 and 4

According to the Quark Model [3], a colorless baryon is composed of three quarks with different colors. From Tables 3 and 4, we can see that there is a term $\Delta$ of the rest masses in each quark. $\Delta$ is a very large unknown constant. Since the rest masses of the quarks in a baryon are very large (from $\Delta$) and the rest mass of the baryon composed by three quarks is not, we infer that there will be a strong binding energy ($E_{Bind} = -3\Delta$) to cancel $3\Delta$ from the three quarks:

$$M_B = m_{q_1}^* + m_{q_2}^* + m_{q_3}^* - |E_{Bind}|.$$  \hspace{1cm} (22)

Thus we will omit the term $\Delta$ in the quark masses and the term $-3\Delta$ in the binding energy from now on. For simplicity’s sake, we only deduced baryons composed of at least two free excited quark $q_N(313)$ ($u(313), d(313)$) since other baryons have much lower possibilities. For these baryons, sum laws are:

- baryon strange number $S_B = S_{q_1} + S_{q_N(313)} + S_{q_N(313)} = S_{q_1(m)}$,
- baryon charmed number $C_B = C_{q_1} + C_{q_N(313)} + C_{q_N(313)} = C_{q_1(m)}$,
- baryon bottom number $B_B = B_{q_1} + B_{q_N(313)} + B_{q_N(313)} = B_{q_1(m)}$,
- baryon electric charge $Q_B = Q_{q_1} + Q_{q_N(313)} + Q_{q_N(313)}$,
- baryon mass $M_B = m_{q_1} + m_{q_N(313)} + m_{q_N(313)}$ (except charmed baryons)
- charmed baryon $M_B = m_{q_1} + m_{q_N(313)} + m_{q_N(313)} + \Delta e$,  \hspace{1cm} (23)

where $\Delta e = 100C(2I-1)$, \hspace{1cm} (24)

where $C$ is the charmed number and $I$ is the isospin of the baryons.

Using sum laws (22) and (23), we can deduce the rest masses and the intrinsic quantum numbers of baryons from the quarks in Tables 3 and 4, as shown in Table 6.
Table 6. The Baryons of the Quarks in Table 3 and Table 4

| $q_i^I$ | $q_j$ | $q_k$ | I  | S  | C  | B  | Q  | M     | Baryon      | Exper.     | $\Delta M / M$% |
|---------|-------|-------|----|----|----|----|----|-------|-------------|------------|---------------|
| $u_1^1(313)$ | u    | d    | $\frac{1}{2}$ | 0  | 0  | 0  | 0  | 1    | p(939)     | p(938)     | 0.11          |
| $d_1^- (313)$ | u    | d    | $\frac{1}{2}$ | 0  | 0  | 0  | 0  | 0    | n(939)     | n(940)     | 0.11          |
| $d_0^0 (493)$ | u    | d    | 0   | -1 | 0  | 0  | 0  | 0    | $\Lambda (1119)$ | $\Lambda^0 (1116)$ | 0.27          |
| $u_0^0 (1753)$ | u    | d    | 0   | 0  | 1  | 0  | 0  | 1    | $\Lambda_0 (2279)$ | $\Lambda^+_c (2285)$ | 0.3           |
| $u_0^0 (1753)$ | u    | u    | 1   | 0  | 1  | 0  | 0  | 2    | $\Sigma^{++} (2479)$ | $\Sigma^{++} (2455)$ | 1.0           |
| $u_0^0 (1753)$ | u    | d    | 1   | 0  | 1  | 0  | 1  | 2    | $\Sigma^+_c (2479)$ | $\Sigma^+_c (2455)$ | 1.0           |
| $u_0^0 (1753)$ | d    | d    | 1   | 0  | 1  | 0  | 0  | 2    | $\Sigma^-_c (2479)$ | $\Sigma^-_c (2455)$ | 1.0           |
| $d_0^0 (4913)$ | u    | d    | 0   | 0  | 0  | -1 | 0  | 0    | $\Lambda (5539)$ | $\Lambda^0 (5624)$ | 1.5           |
| $d_0^0 (773)$ | u    | d    | 0   | -1 | 0  | 0  | 0  | 0    | $\Lambda (1399)$ | $\Lambda (1405)$ | 0.4           |
| $d_0^0 (1933)$ | u    | d    | 0   | -1 | 0  | 0  | 0  | 0    | $\Lambda (2559)$ | $\Lambda (2585)$ | 1.0           |
| $d_0^0 (3753)$ | u    | d    | 0   | -1 | 0  | 0  | 0  | 0    | $\Lambda (4375)$ | $\Lambda (4375)$ | Prediction    |
| $d_0^0 (9613)$ | u    | d    | 0   | -1 | 0  | 0  | 0  | 0    | $\Lambda (10239)$ | $\Lambda (10239)$ | Prediction    |
| $u_0^0 (6073)$ | u    | d    | 0   | 0  | 1  | 0  | 0  | 1    | $\Lambda (6599)$ | $\Lambda^+_c (6599)$ | Prediction    |
| $d_0^0 (9333)$ | u    | d    | 0   | 0  | 0  | -1 | 0  | 0    | $\Lambda^0 (9959)$ | $\Lambda^0 (9959)$ | Prediction    |
| $d_0^0 (1033)$ | d    | d    | 0   | -3 | 0  | 0  | -1 | 1    | $\Omega^- (1659)$ | $\Omega^- (1672)$ | 0.8           |

In the Table, $u \equiv u_1^1 (313)$ and $d \equiv d^- (313)$.

Table 6 shows that the deduced intrinsic quantum numbers (I, S, C, B and Q) of the baryons match experimental results exactly and that the deduced rest masses of the baryons are consistent with more than 98.5% of experimental results.

VII The Mesons of the Quarks in Tables 3 and 4

According to the Quark Model, a colorless meson is composed of a quark $q_i$ with a color and an antiquark $\bar{q}_j$ with the anticolor of $q_i$. For the same flavor, the three pairs of colored quark and antiquark ($q_{iRed} \quad \bar{q}_{jRed} = q_{iYellow} \quad \bar{q}_{jYellow} = q_{iBlue} \quad \bar{q}_{jBlue}$) have the same rest masses and intrinsic quantum numbers (I, S, C, B, Q). Thus we can omit the color when we deduce the rest masses and intrinsic quantum numbers of the mesons. For
**Mesons, the sum laws are**

\[
\begin{align*}
\text{meson strange number } S_M &= S_{q_i} + S_{\bar{q}_j}, \\
\text{meson charmed number } C_M &= C_{q_i} + C_{\bar{q}_j}, \\
\text{meson bottom number } B_M &= B_{q_i} + B_{\bar{q}_j}, \\
\text{meson electric charge } Q_M &= Q_{q_i} + Q_{\bar{q}_j}.
\end{align*}
\]

(25)

There is a strong interaction between the quark and antiquark (colors), but we do not know how large it is. Since the rest masses of the quark and antiquark in mesons are large (from \(\Delta\)) and the rest mass of the meson composed of the quark and antiquark is not, we infer that there will be a large portion of binding energy (\(-2\Delta\)) to cancel \(2\Delta\) from the quark and antiquark and a small amount of binding energy as shown in the following

\[
E_B(q_i,\bar{q}_j) = -2\Delta - 337 + 100\left[\frac{\Delta m}{m_g} + DS - \tilde{m} + \gamma(i,j) - 2I_i I_j\right]
\]

(26)

where \(\Delta = \frac{1}{3}|E_{bind}|\) is \(\frac{1}{3}\) of the baryon binding energy (an unknown large constant, \(\Delta >> m_p = 938\) Mev), \(\Delta m = |m_i - m_j|\), \(DS = |(\Delta S)_i - (\Delta S)_j|\). \(m_g = 939\) (Mev) unless

| \(m_i(\text{or } m_j)\) equals | \(m_C \geq 6073\) | \(m_b \geq 9333\) | \(m_S \geq 9613\) |
|-----------------------------|----------------|----------------|----------------|
| \(m_g\) will equal to       | 1753(Table 4)  | 4913 (Table7) | 3753(Table 4). |

\(\gamma(i,j)\) and \(\gamma(i,j)\) are both ground quarks, \(\gamma(i,j) = 0\). If \(q_i\) and \(q_j\) are not both ground quarks, for \(q_i = q_j\), \(\gamma(i,j) = -1\); for \(q_i \neq q_j\), \(\gamma(i,j) = +1\). \(S_i\) (or \(S_j\)) is the strange number of the quark \(q_i\) (or \(q_j\)). \(I_i\) (or \(I_j\)) is the isospin of the quark \(q_i\) (or \(q_j\)). When we deduce rest masses of mesons, we will omit the \(\Delta\) part in the quark and antiquark mass and omit \(-2\Delta\) binding energy (26).

| \(m_i(\text{or } m_j)\) = | \(m_{q_i} = 313\) | \(m_{d_s} = 493\) | \(m_{u_s} \geq 1753\) | \(m_{d_s} > 3753\), | \(m_{d_s} \geq 4913\) |
|-----------------------------|----------------|----------------|----------------|----------------|----------------|
| \(m_{g_j}\) (or \(m_{g_j}\)) | 313            | 493            | 1753           | 3753,           | 4913. |

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From the quarks in Tables 3 and 4, we can use (25) and (26) to deduce the rest masses and the intrinsic quantum numbers (I, S, C, B and Q) of mesons as shown in Table 7.
Table 7. The Deduced Mesons of the Quarks in Tables 3 and 4

| $q_i^{\Delta S}(m_i)$ | $q_j^{\Delta S}(m_j)$ | $100\Delta m$ | DS | $-100\tilde{m}$ | $E_{bind}$ | Deduced | Experiment | R       |
|------------------------|------------------------|---------------|-----|-----------------|-----------|-----------|------------|---------|
| $q_6^N(313)d_1^S(493)$ | 19 1                   | -100          | -318 | K(488)         | K(494)    | 0.2       |            |         |
| $d_1^S(493)d_1^S(493)$ | 0 0                    | -100          | -437 | $\eta(549)$    | $\eta(548)$ | 0.2       |            |         |
| $u_6^L(1753)q_2^S(493)$ | 134 0                   | -100          | -303 | $D_S(1943)$    | $D_S(1969)$ | 0.4       |            |         |
| $u_6^L(1753)d_2^S(1753)$ | 0 0                    | -100          | -437 | $J/\psi(3069)$ | $J/\psi(3097)$ | 0.9       |            |         |
| $d_1^S(493)d_1^S(4913)$ | 471 0                   | -100          | 34   | $B_S(5440)$    | $B_S(5370)$ | 1.3       |            |         |
| $d_1^S(4913)d_1^S(4913)$ | 337 0                   | -100          | -100 | $B_C(6566)$    | $B_C(6400)$ | 2.6       |            |         |
| $d_1^S(4913)d_1^S(4913)$ | 0 0                    | -100          | -437 | $\Upsilon(9389)$ | $\Upsilon(9460)$ | 0.8      |            |         |
| $d_2^S(773)d_2^S(773)$ | 0 0                    | -68           | -505 | $\eta(1041)$   | $\phi(1020)$ | 2.0       |            |         |
| $d_2^S(773)d_2^S(773)$ | 0 0                    | -424          | -861 | $\eta(3005)$   | $\eta_c(2980)$ | 0.8      |            |         |
| $d_2^S(9333)d_2^S(9333)$ | 0 0                    | -361          | -798 | $\Upsilon(17868)$ | prediction |          |            |         |
| $u_1^L(6073)u_1^L(6073)$ | 0 0                    | -1200         | -1637 | $\psi(10509)$  | $\Upsilon(10355)$ | 1.5      |            |         |
| $d_2^S(1033)d_2^S(1033)$ | 0 0                    | -121          | -558 | $\eta(1508)$   | $f_0(1507)$ | 0.7       |            |         |
| $q_6^N(313)d_2^S(773)$ | 49 1                   | -82           | -170 | K(916)         | K(892)    | 2.7       |            |         |
| $q_6^N(313)d_2^S(3753)$ | 347 1                   | -400          | -190 | K(3876)        | prediction |          |            |         |
| $q_6^N(313)d_2^S(9613)$ | 248 1                   | -256          | -145 | K(9781)        | prediction |          |            |         |
| $q_6^N(313)d_2^S(9333)$ | 183 1                   | -190          | -144 | B(9502)        | prediction |          |            |         |
| $u_1^L(6073)q_2^S(313)$ | 328 1                   | 346.4         | -155 | D(6231)        | prediction |          |            |         |
| $d_2^S(4913)d_2^S(773)$ | 30 2                    | 256.1         | -90  | $\eta(1177)$   | $\eta(1170)$ | 0.6       |            |         |
| $d_2^S(493)d_2^S(3753)$ | 347 2                   | 339.7         | -90  | $\eta(4156)$   | $\psi(4159)$ | 0.07      |            |         |
| $d_2^S(493)d_2^S(9613)$ | 243 2                   | 256.1         | -50  | $\eta(10056)$  | $\Upsilon(10023)$ | 0.4      |            |         |
| $u_1^L(1753)d_2^S(773)$ | 104 2                   | 82.3          | -15  | $D_S(2511)$    | $D_{S_1}(2535)$ | 1.0       |            |         |
| $d_2^S(9613)d_2^S(773)$ | 235 0                   | 211           | -212 | $\eta(10174)$  | $\chi(10232)$ | 0.6       |            |         |

* For $q_6^N(313) \Delta S(313)$, $100\times 2I_i I_j = 50$ and for other pairs $100\times 2I_i I_j = 0$.

Table 7 shows that the deduced intrinsic quantum numbers match experimental results exactly. The deduced rest masses are more than 97% consistent with experimental results.
VIII Predictions

This paper predicts some quarks, baryons and mesons shown in the following list:

| $q_i(m)$ | Baryon[Exper.] | $q_N(m)q_i(m)$ [Exper. ] | $q_i(m)q_{ar{i}}(m)$ [Exper.] |
|----------|----------------|--------------------------|-------------------------------|
| $u_C(6073)$ | $\Lambda_c(6599)$ [?] | $D(6231)$ [?] | $\psi(10509)$ [$\Upsilon(10355)$] |
| $d_S(773)$ | $\Lambda(1399)$ [$\Lambda(1406)$] | $K(916)$ [$K(892)$] | $\eta(1041)$ [$\phi(1020)$] |
| $d_S(1933)$ | $\Lambda(2559)$ [$\Lambda(2585)**$] | $K(2076)$ [$K^*(2045)$] | $\eta(3005)$ [$\eta_c(2980)$] |
| $d_b(9333)$ | $\Lambda_b(9959)$ [?] | $B(9502)$ [?] | $\Upsilon(17868)$ [?] |

$\Lambda(2585)**$ Evidence of existence is only fair.

It is very important to pay attention to the $\Upsilon(3S)$-meson (mass $m = 10,355.2 \pm 0.4$ Mev, full width $\Gamma = 26.3 \pm 3.5$ kev). We compare the mesons $J/\psi(3097)$, $\Upsilon(9460)$ and $\Upsilon(10355)$ shown as follow list

$u_C^1(1753)u_C^1(1753) = J/\psi(3069)$ [$J/\psi(3096.916 \pm 0.011)$, $\Gamma = 91.0 \pm 3.2$kev]  
$d_b^1(4913)d_b^1(4913) = \Upsilon(9389)$ [$\Upsilon(9460.30 \pm 0.26)$, $\Gamma = 53.0 \pm 1.5$kev]  
$u_C^1(6073)u_C^1(6073) = \psi(10509)$ [$\Upsilon(10.355.2 \pm 0.4)$, $\Gamma = 26.3 \pm 3.5$ kev]  

$\Upsilon(3S)$ has more than three times larger of a mass than $J/\psi(1S)$ ($m = 3096.916 \pm 0.011$ Mev) and more than three times longer of lifetime than $J/\psi(1S)$ (full width $\Gamma = 91.0 \pm 3.2$ kev). It is well known that the discovery of $J/\psi(1S)$ is also the discovery of charmed quark $c$ ($u_c(1753)$) and that the discovery of $\Upsilon(9460)$ is also the discovery of bottom quark $b$ ($d_b(4913)$). Similarly the discovery of $\Upsilon(3S)$ will be the discovery of a very important new quark—the $u_C(6073)$-quark.

IX Discussion

1). The fact that physicists have not found any free quark shows that the binding energies are very large. The baryon binding energy $-3\Delta$ (meson - $2\Delta$ ) is a phenomenological approximation of the color’s strong interaction energy in a baryon (a meson). The binding energy $-3\Delta$ ($-2\Delta$) is always cancelled by the corresponding parts $3\Delta$ of the rest masses of the three quarks in a baryon ($2\Delta$ of the quark and antiquark in a meson). Thus we can omit the binding energy $-3\Delta$ (or $-2\Delta$) and the corresponding rest mass
parts $3\Delta$ (or $2\Delta$) of the quarks. This effect makes it appear as if there is no strong binding energy in baryons (or mesons).

2). The energy band excited quarks $u(313)$ and $d(313)$ with $\vec{m} = (0,0,0)$ will be short-lived quarks. They are, however, lowest energy quarks. Since there is no lower energy position that they can decay into, they are not short-lived quarks. Because they have the same rest mass and intrinsic quantum numbers as the free excited quarks $u(313)$ and $d(313)$, they cannot be distinguished from the free excited quarks by experiments. The $u(313)$ and $d(313)$ with $\vec{m} = (0,0,0)$ will be covered up by free excited $u(313)$ and $d(313)$ in experiments since the probability that they are produced is much smaller than the probability that the free excited $u(313)$-quark and $d(313)$-quark are produced. Therefore, we can omit $u(313)$ and $d(313)$ with $\vec{m} = (0,0,0)$. There are only long-lived and free excited $u(313)$ and $d(313)$ quarks in both theory and experiments.

3). The five quarks of the current Quark Model correspond to the five deduced ground quarks [$u \leftrightarrow u(313)$, $d \leftrightarrow d(313)$, $s \leftrightarrow d_s(493)$, $c \leftrightarrow u_c(1753)$ and $b \leftrightarrow d_b(4913)$]. The current Quark Model uses only these five quarks to explain baryons and mesons. In earlier times, this was reasonable, natural and useful. Today, however, it is not reasonable since physicists have discovered many high energy baryons and mesons that need more high energy quarks to compose them.

X Conclusions

1). There is only one elementary quark family $\epsilon$ with three colors and two isospin states ($\epsilon_u$ with $I_Z = \frac{1}{2}$ and $Q = \frac{2}{3}$, $\epsilon_d$ with $I_Z = -\frac{1}{2}$ and $Q = -\frac{1}{3}$) for each color. Thus there are six Fermi ($s = \frac{1}{2}$) elementary quarks with $S = C = B = 0$ in the vacuum. The elementary quarks $\epsilon_u$ and $\epsilon_d$ have SU(2) symmetry.

2). All quarks in hadrons are the excited state of the elementary quark $\epsilon$. There are
two types of excited states: free excited states and energy band excited states. The free excited states are only the u(313)-quark and the d(313)-quark. The energy band excited states are the short-lived quarks, such as \(d_s(493), d_s(773), u_c(1753)\) and \(d_b(4913)\)....

3). There is a large binding energy \(-3\Delta\) (or \(-2\Delta\)) among three quarks in a baryon (or between the quark and the antiquark in a meson). It may be a reason for the quark confinement.

4). Using the phenomenological formulae, we have deduced the rest masses and intrinsic quantum numbers of quarks (Tables 3 and 4), baryons (Table 6) and mesons (Table 7). The deduced intrinsic quantum numbers match the experimental results \([6]\) and \([7]\) exactly. The deduced rest masses of the baryons are more than 98.5% consistent with experimental results \([6]\) and the deduced rest masses of the mesons are more than 97% consistent with experimental results \([7]\).

5). The current Quark Model is the five ground quark approximation of an unborn, more fundamental model.

6). This paper predict some new quarks \([d_S(773), d_S(1933)\) and \(u_C(6073)\]), baryons \([\Lambda_c(6599)\) and \(\Lambda_b(9959)\]) and mesons \([D(6231)\) and \(B(9502)\])

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References

[1] R. M. Eisberg, Fundamentals of Modern Physics, John Wiley & Sons, Inc, 64 (1961).

[2] M. K. Gaillard, P. D. Grannis, and F. J. Sciulli, Rev. Mod. Phys., 71 No. 2 Centenary, S96 (1999).

[3] M. Gell-Mann, Phys. Lett. 8, 214 (1964); G. Zweig, CERN Preprint CERN-Th-401, CERN-Th-412 (1964); Particle Data Group, Phys. Lett. B592, 154 (2004).

[4] J. L. Xu, hep-ph/0502091.

[5] Particle Data Group, Phys. Lett. B592, 37 (2004).

[6] Particle Data Group, Phys. Lett. B592, 66–78 (2004).

[7] Particle Data Group, Phys. Lett. B592, 38–65 (2004).
Figure 1

Figure 1: The regular rhombic dodecahedron. The symmetry points and axes are indicated.

- The axis $\Delta$ (the axis $\Gamma-H$) is a four fold rotation axis
- The axis $\Lambda$ (the axis $\Gamma-P$) is a three fold rotation axis
- The axis $\Sigma$ (the axis $\Gamma-N$) is a two fold rotation axis