A THREE CONFIGURATIONS DIQUARK MODEL FOR BARYONS

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ABSTRACT

The wave functions in the diquark-quark model for baryons are modified to take into account the effect of the different masses of the quarks in diquark formation. A spatial wave function is introduced multiplying each flavour-spin configuration in the quark-diquark model. Furthermore a numerical coefficient is introduced which weighs the contribution of each configuration.
1. Introduction

The concept of diquark was introduced, in the beginnings of the quark model to describe baryonic properties. Diquarks may be conceived as substructures or clusters of pairs of quarks inside baryon wave function [1,2]. Diquark-quark models have been intensively developed in many works on baryon structure and mass spectroscopy, baryon decay and high energy baryon scattering [3]. Some diquark-quark wave functions were constructed to describe the structure of baryons. Those wave functions have the disadvantage of not being completely antisymmetric under exchange of any two quarks. In fact, they are not antisymmetric under the exchange of a quark of the diquark and the third quark. This difficulty is compensated by the simplicity of the model. However, the absence of antisymmetry is consistent with the diquark interpretation as an quasielementary object. Furthermore in the baryon wave function construction [4] mentioned above, it was not taken into account the effect of the difference in the masses of quarks.

The interactions among the quarks inside the baryons are independent of the flavours, but the diquark dimension depends on the masses of the constituent quarks. The higher the quark masses the smaller the dimension of the diquark.

Given a baryon with three quarks of different masses, there are three different configurations of diquark-quark that can contribute to its wave function. The diquarks in each configuration are not equally probable. Another serious distinction in the three possible configurations of the diquark-quark model is that their masses are different. This result constitutes an ambiguity in the diquark-quark model for baryon.

In this paper we give a prescription to construct the baryon wave function, in which the contribution of each diquark-quark configuration is adequately taken into account. The expectation value of the Hamiltonian calculated with the wave function obtained by this prescription gives the baryon mass. The mass of the baryon is, then, the weighed mean value of the masses of the diquark-quark configurations. This mean value eliminates the ambiguity in the computation of the baryon mass. The prescription is applied to the construction of the wave function of the lowest energy baryonic states in S wave with spin 1/2. In these wave functions there exists two spin states, S=0 e S=1, for each S wave diquark. Then each flavour configuration has a scalar and a vectorial diquark.

2. Kinematics and Diquark approximation

The coordinates used in the description of the motion of the three quarks in the
center of mass system of the baryon are

\[ \vec{\rho}_i = \vec{r}_j - \vec{r}_k \]  
(1)

and

\[ \vec{\lambda}_i = \vec{r}_i - \frac{m_j \vec{r}_j + m_k \vec{r}_k}{m_j + m_k} \]  
(2)

The conjugate momenta of these coordinates are

\[ \vec{p}_i = \mu_{jk} \dot{\vec{\rho}}_i \]  
(3)

and

\[ \vec{q}_i = \mu_i \dot{\vec{\lambda}}_i \]  
(4)

where

\[ \mu_{jk} = \frac{m_j m_k}{m_j + m_k} \]  
(5)

\[ \mu_i = \frac{m_i (m_j + m_k)}{m_1 + m_2 + m_3} \]  
(6)

The kinetic energy of the three quarks is

\[ T = \frac{\vec{p}_i^2}{2\mu_{jk}} + \frac{\vec{q}_i^2}{2\mu_i} \]  
(7)

In the diquark model, the potential energy can be written, as

\[ V \approx V_{jk}(\vec{\rho}_i) + V_{i,jk}(\vec{\lambda}_i). \]  
(8)

This is an approximate form of the potential, consistent with the assumption that diquarks are quasielementary objects inside the baryon.

The Hamiltonian of the baryon, in the diquark model, decouples into two Hamiltonians,

\[ H \approx H_{ij} + H_{i,jk} \]  
(9)

The internal motion of the diquark(jk) is described by

\[ H_{jk} = \frac{\vec{p}_i^2}{2\mu_{jk}} + V_{jk}(\vec{\rho}_i) \]  
(10)
and the Hamiltonian of the relative motion of the diquark(jk) and the third quark(i) is

\[ H_{i,jk} = \frac{\vec{q}_i^2}{2\mu_i} + V_{i,jk}(\vec{\lambda}_i) \] (11)

The wave function of the three quarks for the i(jk) quark-diquark configuration factorizes as

\[ \psi_i(\vec{\rho}_i, \vec{\lambda}_i) = \phi_{jk}(\vec{\rho}_i)\chi_i(\vec{\lambda}_i) \] (12)

Assuming that \( \phi_{jk} \) and \( \chi_i \) are respectively eigenfunctions of

\[ H_{jk}\phi_{jk} = E_{jk}\phi_{jk} \] (13)

and

\[ H_{i,jk}\chi_i = E_{i,jk}\chi_i \] (14)

The energy of the configuration i(jk) is given by

\[ E_i = E_{jk} + E_{i,jk} \] (15)

3. Potentials in diquark model

The potentials \( V_{jk}(\vec{\rho}_i) \) and \( V_{i,jk}(\vec{\lambda}_i) \) have the general form

\[ V(\vec{r}) = V(r) + U_{spin}(\vec{r}) \] (16)

The spherically symmetric part of the potential can be written as

\[ V(r) = C + V_v(r) + V_s(r) \] (17)

\[ V_v(r) = V_{coul}(r) + (1 - f)V_{conf}(r), \] (18)

where

\[ V_s(r) = fV_{conf}(r) \] (19)

\[ V_{coul} = -FG\frac{\alpha_s}{r} \] (20)

and
\[ V_{\text{conf}} = K r^{\frac{3}{2}} \]  

The parameter \( f \) controls the proportion of scalar and vectorial parts under Lorentz transformation of the confining potential [5,6].

For each pair \((ij)\) of particles, \( F_G \) is given by

\[ F_G = \langle \vec{F}_i \cdot \vec{F}_j \rangle = F_{ij}^2 - F_i^2 - F_j^2 \]  

where \( F_i^2 \) is the expectation value of the quadratic Casimir operator for the colour group SU(3) in the \( (i) \) multiplet.

The parameter \( C \) depends on the masses of the interacting particles \((ij)\) according to

\[ C(m_i, m_j) = a_0 + a_1 x + a_2 x^2, \]  

where

\[ x \equiv \ln \left( \frac{m_i^2 m_j + m_i m_j^2}{m_i m_j^2} \right). \]

The running coupling constant of chromodynamics, \( \alpha_s \), and the parameter \( K \) of the confining potential are assumed to be constant for a given colour system and independent of the masses of the interacting particles.

The potential defined by eqs. (14) to (21) was applied to the study of the spectroscopy of the mesons \((q\bar{q})\) [6], glueballs [7], and hybrids \((q\bar{q}g)\) [8]. The masses of the quarks and the parameters of the potential used in this work are shown in Table[1].

The spin-dependent terms of the potential can be obtained from the Breit-Fermi Hamiltonian, [9].

In this paper, only S-wave states are computed. Then the only contributing spin dependent term is

\[ V_{ss} = \left( \frac{2}{3m_1 m_2} \right) \nabla^2 V_r(\vec{S}_1 \cdot \vec{S}_2). \]  

The lowest energy states can be obtained by a variational approach, choosing gaussian wave functions

\[ \phi(r) = \left( \frac{2}{\pi} \right)^{3/4} \frac{1}{r^{3/2}} e^{\exp \left[-\left( \frac{r}{r_0} \right)^2 \right]} . \]  

The energy and radius \( \rho_0 \) of the diquark\((jk)\) are given by minimizing
\[ E_{jk} \leq <\phi_{jk} | H_{jk} | \phi_{jk}>. \] (27)

Similarly, the energy and radius \(\lambda_o\) of the configuration \(i(jk)\) are obtained by minimizing

\[ E_{i,jk} \leq <\chi_i | H_{i,jk} | \chi_i>. \] (28)

In tables (1) to (4), we show the results of these computations.

### 4. The baryon wavefunctions in quark-diquark model

Diquarks are assumed to be antitriplet colour states, which are formed by two colour triplets, the quarks interacting attractively [10].

The flavour-spin wave functions of the diquarks are denoted by:

\[ V_{+1}(q'q) = \frac{1}{\sqrt{2}}(qq' + q'q) \otimes (\uparrow\uparrow) \] (29a)

\[ V_{+1}(q'q) = \frac{1}{\sqrt{2}}(qq' + q'q) \otimes \frac{1}{\sqrt{2}}(\uparrow\downarrow + \downarrow\uparrow) \] (29b)

\[ V_0(q'q) = \frac{1}{\sqrt{2}}(qq' + q'q) \otimes (\downarrow\downarrow) \] (29c)

\[ S(q'q) = \frac{1}{\sqrt{2}}(qq' - q'q) \otimes \frac{1}{\sqrt{2}}(\downarrow\uparrow - \uparrow\downarrow) \] (29d)

where \(q,q'=(u,d,s,c,b)\).

The baryon wave functions in the quark-diquark model [4] can be modified to take into account the effect of the difference in quark masses. This is done by introducing in the baryon wave functions [11] a factor multiplying each quark-diquark configuration \(q_a(q_bq_c)\), which distinguishes among the contributions of each configuration. These factors are given by

\[ \alpha_a = \left( \frac{\lambda_s^a}{\rho_{bc}} \right)^{\nu_a}, \] (30)

where \((bc)\) is a scalar diquark, and

\[ \beta_a = \left( \frac{\lambda_v^a}{\rho_{bc}^v} \right)^{\nu_a}, \] (31)
where \((bc)\) is a vectorial diquark; \(\rho_{bc}^s\) and \(\rho_{bc}^v\) are the r.m.s radii of the scalar and vectorial \((bc)\) diquarks, respectively. The r.m.s radii of the configuration \(a(bc)\) are \(\lambda_a^s\) and \(\lambda_a^v\) for scalar and vectorial diquark \((bc)\), respectively. The parameters \(\nu_a\) are fixed by imposing orthogonality on the baryon wave functions. The spatial wave functions of a quark-diquark flavour configuration \(a(bc)\) will be denoted by \(\phi_a^s\) or \(\phi_a^v\), according as the diquark \((bc)\) spin is 0 or 1.

The wave functions for baryons in the flavour SU(3) octet, \((uds)\), in the quark-diquark model, are given by

\[
| p, \pm > = \pm F_p \left\{ \beta_u [V_0(ud) u_\pm - \sqrt{2} V_\pm (ud) u_{\mp}] \phi_u^s + \beta_d [-\sqrt{2} V_0(uu) d_\pm + 2 V_\pm (uu) d_{\mp}] \phi_d^v + \right.
\]

\[
\left. \pm 3 \alpha_u S(ud) u_\pm \phi_u^s \right\} \quad (32a)
\]

\[
| n, \pm > = \pm F_n \left\{ \beta_d [V_0(du) d_\pm - \sqrt{2} V_\pm (du) d_{\mp}] \phi_d^v + \beta_u [-\sqrt{2} V_0(dd) u_\pm + 2 V_\pm (uu) u_{\mp}] \phi_u^s + \right.
\]

\[
\left. \pm 3 \alpha_d S(du) d_\pm \phi_d^v \right\} \quad (32b)
\]

\[
| \Sigma^+, \pm > = \pm F_{\Sigma^+} \left\{ \beta_u [V_0(us) u_\pm - \sqrt{2} V_\pm (us) u_{\mp}] \phi_u^s + \beta_s [-\sqrt{2} V_0(uu) s_\pm + 2 V_\pm (uu) s_{\mp}] \phi_s^v + \right.
\]

\[
\left. \pm 3 \alpha_u S(us) u_\pm \phi_u^s \right\} \quad (32c)
\]

\[
| \Sigma^-, \pm > = \pm F_{\Sigma^-} \left\{ \beta_d [V_0(ds) d_\pm - \sqrt{2} V_\pm (ds) d_{\mp}] \phi_d^v + \beta_s [-\sqrt{2} V_0(dd) s_\pm + 2 V_\pm (dd) s_{\mp}] \phi_s^v + \right.
\]

\[
\left. \pm 3 \alpha_d S(ds) d_\pm \phi_d^v \right\} \quad (32d)
\]

\[
| \Sigma^0, \pm > = \pm F_{\Sigma^0} \left\{ \beta_u [V_0(ds) u_\pm - \sqrt{2} V_\pm (ds) u_{\mp}] \phi_u^s + \beta_d [V_0(us) d_\pm - \sqrt{2} V_\pm (us) d_{\mp}] \phi_d^v - \right.
\]

\[
\left. - 2 \beta_s [V_0(ud) s_\pm - \sqrt{2} V_\pm (ud) s_{\mp}] + \phi_s^v \pm 3 [\alpha_d S(su) d_\pm \phi_d^s + \alpha_u S(ds) u_\pm \phi_u^s] \right\} \quad (32e)
\]
The wave functions of all baryons denoted by \( (A,B,C) = (u,d,s,c,b) \) can be written in any one of the general forms:

\[
| \Lambda^0, \pm > = \pm F_{\Lambda^0} \left\{ \beta_d [-V_0(us)d_\pm - \sqrt{2}V_\pm(us)d_\mp] \phi_d^\pm + \beta_u [V_0(ds)u_\pm - \sqrt{2}V_\pm(ds)u_\mp] \phi_u^\pm + \right.
\]
\[
\left. \mp [\alpha_u S(ds)u_\mp \phi_u^\pm + \alpha_d S(us)d_\mp \phi_d^\pm - 2\alpha_s S(du)s_\mp \phi_s^\pm] \right\} \quad (32f)
\]

\[
| \Xi^0, \pm > = \pm F_{\Xi^0} \left\{ \beta_s [V_0(us)s_\pm - \sqrt{2}V_\pm(us)s_\mp] \phi_s^\pm + \beta_u [-\sqrt{2}V_0(su)u_\pm + 2V_\pm(su)u_\mp] \phi_u^\pm + \right.
\]
\[
\left. \pm 3\alpha_s S(us)s_\pm \phi_s^\pm \right\} \quad (32g)
\]

\[
| \Xi^-, \pm > = \pm F_{\Xi^-} \left\{ \beta_s [V_0(ds)s_\pm - \sqrt{2}V_\pm(ds)s_\mp] \phi_s^\pm + \beta_d [-\sqrt{2}V_0(ss)d_\pm + 2V_\pm(ss)d_\mp] \phi_d^\pm + \right.
\]
\[
\left. \pm 3\alpha_s S(ds)s_\pm \phi_s^\pm \right\} \quad (32h)
\]

The wave functions of all baryons denoted by \( (A,B,C) = (u,d,s,c,b) \) can be written in any one of the general forms:

\[
| AAB, \pm > = \pm F_1 \left\{ \beta_A [V_0(AB)A_\pm - \sqrt{2}V_\pm(AB)A_\mp] \phi_A^\pm \right.
\]
\[
\left. + \beta_B [-\sqrt{2}V_0(AA)B_\pm + 2V_\pm(AA)B_\mp] \phi_B^\pm + \pm 3\alpha_A S(AB)A_\pm \phi_A^\pm \right\} \quad (33a)
\]

\[
| ABC, \pm > = \pm F_2 \left\{ \beta_A [V_0(BC)A_\pm - \sqrt{2}V_\pm(BC)A_\mp] \phi_A^\pm \right.
\]
\[
\left. + \beta_B [V_0(AC)B_\pm - \sqrt{2}V_\pm(AC)B_\mp] \phi_B^\pm + \right.
\]
\[
\left. - 2\beta_C [V_0(AB)C_\pm - \sqrt{2}V_\pm(AB)C_\mp] \phi_C^\pm + \pm 3[\alpha_A S(BC)A_\pm \phi_A^\pm + \alpha_B S(AC)B_\pm] \phi_B^\pm \right\} \quad (33b)
\]

\[
| ABC, \pm > = \pm F_3 \left\{ \beta_A [V_0(BC)A_\pm - \sqrt{2}V_\pm(BC)A_\mp] \phi_A^\pm \right.
\]
\[
\left. + \beta_B [-V_0(AC)B_\pm - \sqrt{2}V_\pm(AC)B_\mp] \phi_B^\pm \right. \quad (33c)
\]
\[ \pm \{ \alpha_A S(CB) A \pm \phi_A^s + \alpha_B S(CA) B \pm \phi_B^s - 2 \alpha_C S(AB) C \pm \phi_C^s \} \}. \tag{33c} \]

The normalization constants are

\[ F_1 = (9\alpha_A^2 + 3\beta_A^2 + 6\beta_B^2)^{-1/2} \tag{34a} \]
\[ F_2 = \left( 9(\alpha_A^2 + \alpha_B^2) + 3(\beta_A^2 + \beta_B^2 + 4\beta_C^2) \right)^{-1/2} \tag{34b} \]
\[ F_3 = \left( \alpha_A^2 + \alpha_B^2 + 4\alpha_C^2 + 3(\beta_A^2 + \beta_B^2) \right)^{-1/2} \tag{34c} \]

The orthogonality conditions, which determine the values of the parameters \( \nu_a \), are

\[ 2 < ABC, \pm | ABC, \pm >_3 = 0, \tag{35} \]

which gives

\[ (\beta_A^2 - \beta_B^2) - (\alpha_A^2 - \alpha_B^2) = 0 \tag{36} \]

The values of the parameters \( \nu_a \) satisfying these conditions are given in Table [2]. The values of \( \nu_a \) for states like \( | AAB, \pm >_1 \) are undetermined by these conditions, and are assumed to be \( \nu_a = 0.6 \), a mean value in the interval \([0.2,1.0]\) that contains the values of \( \nu_a \) shown in Table [2]. Choosing \( \nu_a = 0.6 \), we have a general value that gives the lowest values for the masses of states like \( | AAB >_1 \), which is consistent with a linear variation function approach for baryon wave functions.

Using the above defined notations (32), the wave functions of the spin 1/2 charmed baryons pertaining to 20-plet of the flavour SU(4) can be written as in Table [3]. Similarly, the wave functions of the spin 1/2 baryons with bottom flavour are shown in Table [4]. The values of the factors \( \alpha \) and \( \beta \) defined in eqs (30,31), multiplying each flavour configuration \( a(bc) \), are listed in Tables [5] and [6].

The differences in the values of the \( \alpha_a, \alpha_b, \alpha_c \) and \( \beta_a, \beta_b, \beta_c \) for a baryon with flavours \( a,b,c \) show that the formation of the diquarks \( (bc), (ac) \) and \( (ab) \) are not equally probable inside the baryon. The most probable configuration is the one in which the lightest quark is outside the diquark.

The mass of the baryon with quarks \( A,B,C \) is given by

\[ M_{(A,B,C)} = m_a + m_b + m_c + < ABC | H | ABC >. \tag{37} \]
The expectation values of the Hamiltonian for each one of the states (33) are

\[ E_{(AAB)1} = F_1^2 (3\beta_A^2 E_{(AB)A} + 6\beta_B^2 E_{(AA)B} + 9\alpha_A^2 E_{(AB)A}) \]  

(38a)

\[ E_{(ABC)2} = F_2^2 \left( 3\beta_A^2 E_{(BC)A} + 3\beta_B^2 E_{(AC)B} + 12\beta_C^2 E_{(AB)C} + 9(\alpha_A^2 E_{(BC)A} + \alpha_B^2 E_{(AC)B}) \right) \]  

(38b)

\[ E_{(ABC)3} = F_3^2 \left( 3\beta_A^2 E_{(BC)A} + 3\beta_B^2 E_{(AC)B} + \alpha_A^2 E_{(BC)A} + \alpha_B^2 E_{(AC)B} + 4\alpha_C^2 E_{(AB)C} \right) \]  

(38c)

The masses of the spin 1/2 S-wave baryons obtained by our method are shown in Tables [7] and [8], and compared with the existing experimental values.

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Table [1]-values of parameters

| Parameter | Value       |
|-----------|-------------|
| \( m_u = m_d \) | 0.38 GeV    |
| \( m_s \)       | 0.5 GeV     |
| \( m_c \)       | 1.5 GeV     |
| \( m_b \)       | 4.5 GeV     |
| \( a_0 \)       | 0.0010      |
| \( a_1 \)       | 0.146       |
| \( a_2 \)       | -1.412      |
| \( f \)         | 0.5         |
| \( \alpha_s \)  | 0.187       |
| \( K \)         | 0.767       |
| \( F_G \)       | -2/3 (diquark) |
| \( F_G \)       | -4/3 (meson) |

Table [2]-Values of the parameters \( \nu_a \), for the quark-diquark configurations a(bc). Where (q=u,d).

| Bar. | \( \nu_q \) | \( \nu_s \) | \( \nu_c \) | \( \nu_b \) |
|------|-------------|-------------|-------------|-------------|
| qsc  | 0.6957      | 0.9824      | 0.5         | -           |
| qsb  | 0.3934      | 0.5         | -           | 0.4443      |
| qcb  | 0.7811      | -           | 0.5         | 0.9823      |
| scb  | -           | 0.3472      | 0.5         | 0.2493      |
Table[3]-Wave functions, in the quark-diquark model, for baryons with charm flavour, in the spin 1/2 S wave.

| Wave Functions with charm quark |
|--------------------------------|
| \( | \Sigma^+_{c^+}, \pm > \) = | uuc, \pm \geq 1 ; | \Sigma^-_{c^+}, \pm > \) = | udc, \pm \geq 2 |
| \( | \Sigma^0_{c^+}, \pm > \) = | ddc, \pm \geq 1 ; | \Lambda^+_c, \pm > \) = | udc, \pm \geq 3 |
| \( | \Xi^+_{c^+}, \pm > \) = | usc, \pm \geq 2 ; | \Xi^{*+}_{c^+}, \pm > \) = | usc, \pm \geq 3 |
| \( | \Xi^0_{c^+}, \pm > \) = | dsc, \pm \geq 2 ; | \Xi^{0*}_{c^+}, \pm > \) = | dsc, \pm \geq 3 |
| \( | \Omega^0_{c^+}, \pm > \) = | ssc, \pm \geq 1 ; | \Omega^{++}_{cc}, \pm > \) = | ccs, \pm \geq 1 |
| \( | \Xi^{++}_{cc}, \pm > \) = | ccu, \pm \geq 1 ; | \Xi^+_{cc}, \pm > \) = | ccd, \pm \geq 1 |

Table[4]-Wave functions, in the quark-diquark model, for baryons with bottom flavour, in the spin 1/2 S wave.

| Wave Functions with bottom quark |
|--------------------------------|
| \( | \Sigma^+_{b^-}, \pm > \) = | uub, \pm \geq 1 ; | \Sigma^-_{b^-}, \pm > \) = | udb, \pm \geq 2 |
| \( | \Sigma^0_{b^-}, \pm > \) = | ddb, \pm \geq 1 ; | \Lambda^0_{b^-}, \pm > \) = | udb, \pm \geq 3 |
| \( | \Xi^0_{b^-}, \pm > \) = | usb, \pm \geq 2 ; | \Xi^{0*}_{b^-}, \pm > \) = | usb, \pm \geq 3 |
| \( | \Xi^-_{b^-}, \pm > \) = | dsb, \pm \geq 2 ; | \Xi^{-*}_{b^-}, \pm > \) = | dsb, \pm \geq 3 |
| \( | \Omega^-_{b^-}, \pm > \) = | sbb, \pm \geq 1 ; | \Omega^{-+}_{bb}, \pm > \) = | sbb, \pm \geq 1 |
| \( | \Xi^{++}_{bb}, \pm > \) = | bbu, \pm \geq 1 ; | \Xi^{--}_{bb}, \pm > \) = | ddb, \pm \geq 1 |
| \( | \Xi^0_{cb}, \pm > \) = | ucb, \pm \geq 2 ; | \Xi^{*+}_{cb}, \pm > \) = | ucb, \pm \geq 3 |
| \( | \Xi^0_{scb}, \pm > \) = | dcb, \pm \geq 2 ; | \Xi^{0*}_{cb}, \pm > \) = | dcb, \pm \geq 3 |
| \( | \Omega^0_{bbc}, \pm > \) = | bbc, \pm \geq 1 ; | \Omega^{++}_{ccb}, \pm > \) = | ccb, \pm \geq 1 |
Table [5]-Values of the factors $\alpha_a$ for configuration $a(bc)$ with scalar diquark $(bc)$. Where $(q=u,d)$.

| diquark | $\alpha_q$ | $\alpha_s$ | $\alpha_c$ | $\alpha_b$ |
|---------|-----------|-----------|-----------|-----------|
| qq      | 0.8443    | 0.7818    | 0.6891    | 0.6468    |
| qs      | 0.8508    | 0.7860    | 0.7263    | 0.7127    |
| ss      | 0.8664    | -         | 0.6855    | 0.6301    |
| qc      | 0.8664    | 0.6779    | 0.6394    | 0.3824    |
| sc      | 0.8655    | 0.8571    | 0.6713    | 0.7979    |
| cc      | 1.0358    | 0.9825    | -         | 0.6438    |
| qb      | 0.8627    | 0.8153    | 0.6550    | 0.4809    |
| sb      | 0.9290    | 0.8655    | 0.6909    | 0.5119    |
| cb      | 1.1864    | 1.0369    | 0.8412    | 0.6394    |
| bb      | 1.3091    | 1.2346    | 0.9754    | -         |

Table [6]-Values of the factors $\beta_a$ for configuration $a(bc)$ with scalar diquark $(bc)$. Where $(q=u,d)$.

| diquark | $\beta_q$ | $\beta_s$ | $\beta_c$ | $\beta_b$ |
|---------|-----------|-----------|-----------|-----------|
| qq      | 0.4411    | 0.6776    | 0.5927    | 0.5601    |
| qs      | 0.7719    | 0.6966    | 0.6542    | 0.6531    |
| ss      | 0.7964    | -         | 0.6152    | 0.5702    |
| qc      | 0.8117    | 0.5980    | 0.5853    | 0.3375    |
| sc      | 0.8047    | 0.8114    | 0.6224    | 0.7725    |
| cc      | 1.001     | 0.9477    | -         | 0.6111    |
| qb      | 0.8217    | 0.7758    | 0.5943    | 0.3937    |
| sb      | 0.9011    | 0.8249    | 0.6448    | 0.4457    |
| cb      | 1.1454    | 1.0199    | 0.8145    | 0.6061    |
| bb      | 1.2861    | 1.2122    | 0.9530    | -         |
Table [7]-Masses (in GeV) of S wave and spin 1/2 baryons with experimental datas [12].

| Flavour | Baryon | Our Results | Experimental |
|---------|--------|-------------|--------------|
| uud     | p      | 1.0402      | 0.9383       |
| udd     | n      | 1.0402      | 0.9396       |
| uus     | Σ⁺     | 1.2064      | 1.1894       |
| uds     | Σ⁰     | 1.2064      | 1.1974       |
| uds     | Λ⁰     | 1.1823      | 1.1156       |
| dds     | Σ⁻     | 1.2064      | 1.1926       |
| uss     | Ξ⁰     | 1.3381      | 1.3149       |
| dss     | Ξ⁻     | 1.3381      | 1.3213       |
| uuc     | Σ⁺⁺    | 2.5193      | 2.453        |
| udc     | Σ⁺     | 2.5193      | 2.453± 0.003 |
| udc     | Λ⁺     | 2.4296      | 2.285        |
| ddc     | Σ⁰     | 2.5193      | 2.453        |
| udb     | Σₐ     | 5.8639      | 5.641± 0.050 |
Table [8]-Masses (in GeV) of S wave and spin 1/2 baryons without experimental datas.

| Flavour | Baryon | Our Results  |
|---------|--------|--------------|
| usc     | $\Xi^+_c, \Xi^0_c$ | 2.6534, 2.5843 |
| dsc     | $\Xi^0_c, \Xi^0_c$ | 2.6534, 2.5843 |
| ssc     | $\Omega^0_c$ | 2.7536 |
| ucc     | $\Xi^{++}_{cc}$ | 3.7580 |
| dcc     | $\Xi^+_{cc}$ | 3.7580 |
| ssc     | $\Omega^+_{cc}$ | 3.8607 |
| uub     | $\Sigma^+_b$ | 5.9862 |
| ddb     | $\Sigma^-_b$ | 5.9862 |
| usb     | $\Xi^+_b, \Xi^0_b$ | 6.1154, 6.0214 |
| dsb     | $\Xi^-_b, \Xi^-_b$ | 6.1154, 6.0214 |
| ssb     | $\Omega^-_b$ | 6.1948 |
| ucb     | $\Xi^{+}_{cb}, \Xi^{+*}_{cb}$ | 7.0949, 7.1241 |
| dcg     | $\Xi^0_{cb}, \Xi^{0*}_{cb}$ | 7.0949, 7.1241 |
| scb     | $\Xi^0_{scb}, \Xi^{0*}_{scb}$ | 7.1719, 7.1997 |
| ccb     | $\Omega^+_{ccb}$ | 8.2060 |
| ubb     | $\Xi^0_{bb}$ | 10.3836 |
| ddb     | $\Xi^-_{bb}$ | 10.3836 |
| sbb     | $\Omega^-_{bb}$ | 10.4961 |
| cbb     | $\Omega^0_{bbc}$ | 10.4961 |

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