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FIVE QUARK MODELS AND MAGNETIC MOMENTS OF BARYONS. II

By A. L. Choudhury

Departments of Physics and Mathematics, Elizabeth City State University, Elizabeth City*

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Assuming that the magnetic moment operator transforms as ($\underline{\underline{24}}$, 3_s) component of the $\underline{\underline{220}}$-representation of U(10), we computed the magnetic moments of the fancy particles, at first in the C–C′ model of Achiman, Kollar and Walsh and then in an alternate model where the new quark has a charge $Q = -1/3$. As expected all results in U(8) stayed unchanged, and we expressed the magnetic moments of the particles with new quantum number fancy in terms of the magnetic moment of the proton.

1. *Introduction*

In a preceding paper [1] we have described how magnetic moments could be calculated in a five quark model, first introduced by Achiman, Kollar and Walsh [2]. Their C−C′ version needs another extra quark f, with charge $Q = 2/3$. This model has been used by the author [3] to calculate the magnetic moments for vector bosons and the transition magnetic moments between pseudoscalar and vector mesons. The U(5) group, which was supposed to describe the intrinsic symmetry quantum numbers, was extended to incorporate the intrinsic spin of the particles. Following Gürsey and Radicati, and Sakita [4] who extended SU(3) to SU(6) to include spin, we enlarge the symmetry group from U(5) to U(10). Taking this group as the basis, and following the technique used by Bég, Lee and Pais [5], Choudhury [6] compared the magnetic moments of the vector mesons, in terms of the magnetic moments of ϱ-mesons. These results could also be claimed to be the results of SU(10), because the magnetic moment operator did not depend on the parameter, which would contribute trace term of the operator. The results also include the prediction for the magnetic moments of the ψ-particle. If the Y-particle [7] is considered to be bound $f\bar{f}$ ground state [8] then we obtained a definite magnetic moment ratio between Y-particle and ϱ^0-particle (see Ch1).

* Address: Department of Physics & Mathematics, Elizabeth City State University, Elizabeth City, North Carolina 27909, USA.

As we are tempted to describe the Y-family to be the indication of the emergence of new family of baryons, we would try to extend the results of the magnetic moments of the baryons in the U(10)-symmetry. The procedure is exactly similar to the case obtained by Choudhury and Joshi (reference CJ2) [6] who calculated the moments of the charmed baryons under the U(8)-symmetry. In this paper we assume that the magnetic moment operator transforms as $(\underline{23}, 3_s)$-component of U(5)⊗SU(2). We place the baryons in $\underline{\underline{220}}$-representation of U(10), which contains a $\underline{\underline{35}}$-representation with spin 3/2 and $\underline{\underline{40}}$-representation with spin 1/2. Following the same procedure as in CJ2, we can express all magnetic moments in terms of the proton magnetic moment.

We are aware of the fact that the symmetry breaking terms would change the results of moments considerably, as pointed out by Lichtenberg [8]. However we think that the results we would be quoting in this paper would be a guideline in comparing with experiments and consequently determine the magnitude of the symmetry breaking interactions.

In computing our results we use two models as mentioned in the preceding paper. The first model is the C–C′ model of Achiman, Kollar and Walsh [2], with f-quark having a charge $Q = 2/3$ as we have mentioned earlier. We also include the results of an alternative model where f-quark has charge $-1/3$. This inclusion is due to the fact that the experimental results are showing (although not with hundred percent certainty) a kind of bias for the alternative quark charge.

In Section 2 we outline the U(10)-classification. We prescribe there how to construct current tensors and calculate the magnetic moment. In Section 3, we systematically compare the magnetic moments of different particles and the transition moments between them. In Section 4, we use the alternative model (the fancy quark having a charge $Q = -1/3$) to determine the magnetic moments and the transition magnetic moments. In Section 5, we discuss our results.

2. *U(10)-representation of five quark models*

The U(10)-symmetry is the natural extension of the five quark model which allows us to incorporate the spin of the particles. The symmetry U(10) has a subgroup U(5) ⊗ SU(2). The group U(5) should represent the internal symmetry of the particles whereas SU(2) should represent their spin components. Similar to the work of Choudhury [6], where vector boson magnetic moments have been calculated, we proceed to construct baryons which are qqq combination of the quarks, with appropriate spin orientations. As usual, we are assuming that the baryons are color singlets, but if we suppress the color specification, they are totally symmetric with respect to U(10) indices. We would assume that they belong to the representation [3000000000] of dimension $\underline{\underline{220}}$. This representation is composed of the following U(5) ⊗ SU(2) multiplets:

$$\underline{\underline{220}} = (\underline{\underline{35}}, 4_s) + (\underline{\underline{40}}, 2_s), \tag{1}$$

where $\underline{\underline{220}}$ is a U(10)-representation and $(\underline{\underline{m}}, n_s)$ means that it belongs to $\underline{\underline{m}}$-component of the U(5)-symmetry and n_s-representation of SU(2). As usual the totally symmetric tensor in U(10) can be represented by

$$B_{ABC} = B_{(am)(bn)(cp)} = \mathfrak{B}_{abc}\chi_{mnp}+\tfrac{1}{3}\left[\varepsilon_{mp}\chi_n\mathfrak{B}_{\{ac\}b}+\varepsilon_{nm}\chi_p\mathfrak{B}_{\{ba\}c}+\varepsilon_{pn}\chi_m\mathfrak{B}_{\{cb\}a}\right], \tag{2}$$

where the states $\mathfrak{B}_{abc}$ and $\mathfrak{B}_{\{ac\}b}$ are the Eqs. (5) and (8) of reference Ch1. The tensors χ_{mnp}, $\varepsilon_{mn}\chi_p$ are well known SU(2) tensors representing spin 3/2 and 1/2 particles respectively (see for example Eqs. (5) and (6) of reference CJ2). The suffixes a, b, and c run from 1 through 5, whereas m, n, and p are SU(2) indices which run from 1 through 2 The most general current tensor $J^{A'}{}_A$ is given by

$$J^{A'}{}_A = \mu_0\overline{B}^{A'BC}B_{ABC}+g_0\delta^{A'}{}_A\overline{B}^{DBC}B_{DBC}. \tag{3}$$

Assuming now that the magnetic moment operator transforms as ($\underline{\underline{24}}$, 3_s) -component of U(10)-symmetry and following Bég, Lee and Pais [5], we can write, in the effective low frequency limit the magnetic moment component of the electromagnetic vertex as

$$M = \mu_0(p)J^{A'}{}_A\vec{\sigma}^m{}_{m'}\cdot\vec{n}Q^a{}_{a'}. \tag{4}$$

Using Eqs. (2)–(4) and carrying out a lengthy calculation identical to those in reference CJ2, we find the most general contribution to the magnetic moment operator

$$M(\overline{\underline{\underline{40}}}, \underline{\underline{40}}) = -\tfrac{2}{9}\, i\mu_0\mu_0(\mathrm{p})\vec{n}\cdot\langle\overline{\chi}\vec{\sigma}\chi\rangle_{1/2}[\overline{\mathfrak{B}}^{\{a'c\}b}\mathfrak{B}_{\}ac\}b}+5\overline{\mathfrak{B}}^{\{cb\}a'}\mathfrak{B}_{\{ac\}b}]Q^a{}_{a'}, \tag{5a}$$

$$M(\overline{\underline{\underline{35}}}, \underline{\underline{35}}) = i\mu_0\mu_0(\mathrm{p})\vec{n}\cdot\langle\overline{\chi}\vec{\sigma}\chi\rangle_{3/2}\overline{\mathfrak{B}}^{a'bc}\mathfrak{B}_{abc}Q^a{}_{a'}, \tag{5b}$$

$$M(\overline{\underline{\underline{35}}}, \underline{\underline{40}}) = \tfrac{2}{3}\,\mu_0\mu_0(\mathrm{p})\vec{n}\cdot\langle\overline{\chi}_{3/2}\vec{\sigma}\chi_{1/2}\rangle\overline{\mathfrak{B}}^{a'bc}\mathfrak{B}_{\{ab\}c}Q^a{}_{a'}, \tag{5c}$$

and

$$M(\overline{\underline{\underline{40}}}, \underline{\underline{35}}) = \tfrac{2}{3}\,\mu_0\mu_0(\mathrm{p})\vec{n}\cdot\langle\overline{\chi}_{1/2}\vec{\sigma}\chi_{3/2}\rangle\overline{\mathfrak{B}}^{\{a'b\}c}\mathfrak{B}_{abc}Q^a{}_{a'}. \tag{5d}$$

In Eqs. (4) and (5) we have set $\vec{n} = \vec{q}\times\vec{\varepsilon}$, where $\vec{q}$ is the momentum of the baryon and $\vec{\varepsilon}$ is the polarization vector perpendicular to $\vec{q}$. The spin factors have the following meaning:

$$\langle\overline{\chi}\vec{\sigma}\chi\rangle_{1/2} = \overline{\chi}^m\vec{\sigma}^p{}_m\chi_p, \tag{6a}$$

$$\langle\overline{\chi}\vec{\sigma}\chi\rangle_{3/2} = \overline{\chi}^{mnp}\vec{\sigma}^q{}_m\chi_{qnp}, \tag{6b}$$

$$\langle\overline{\chi}_{3/2}\vec{\sigma}\chi_{1/2}\rangle = \overline{\chi}^{mnp}\vec{\sigma}^q{}_m\varepsilon_{qn}\chi_p, \tag{6c}$$

and

$$\langle\overline{\chi}_{1/2}\vec{\sigma}\chi_{3/2}\rangle = \varepsilon^{mn}\overline{\chi}^p\vec{\sigma}^q{}_m\chi_{qnp}. \tag{6d}$$

We express now the expectation value of the magnetic moment of a particle X as μ(X) defined by the relation

$$\mu(\mathrm{X}) = \langle \mathrm{X}; J, J_z = J|M|\mathrm{X}; J, J_z = J\rangle. \tag{7}$$

We also define the transition moment between a particle X belonging to $\underline{\underline{40}}$-representation and Y belonging to $\underline{\underline{35}}$-representation with the symbol $\langle\mathrm{Y}|\mu|\mathrm{X}\rangle$ as

$$\langle\mathrm{Y}|\mu|\mathrm{X}\rangle = \langle\mathrm{Y}; J = \tfrac{3}{2}, J_z = \tfrac{1}{2}\,|M|\mathrm{X}; J = \tfrac{1}{2}, J_z = \tfrac{1}{2}\rangle. \tag{8}$$

Using Eqs. (5) and the definition of tensors $\mathfrak{B}_{(ab)c}$ and $\mathfrak{B}_{abc}$, given by Eqs. (5) and (8) in reference Ch1, we can easily compute the magnetic moments of all baryons. The results are given in the next Section.

3. *Magnetic moments of the baryons*

The magnetic moments of the baryons can now be compared with the magnetic moment of the proton. For particles with $C' = 0$, the results are similar to those obtained in the U(4)-symmetry. For the sake of completeness, we just quote the essential results.

3.1. Baryons belonging to $\underline{\underline{40}}$-representation of U(5)

3.1.1. $C' = 0$ and particles belonging to $\underline{20}'$-representation of U(4)
For particles with $C' = 0$ and belonging to SU(3) octet, we have

$$-\tfrac{3}{2}\mu(\mathrm{n}) = \mu(\Sigma^+) = -\tfrac{3}{2}\mu(\Xi^0) = -3\mu(\Sigma^-) = -3\mu(\Xi^-)$$

$$= 3\mu(\Sigma^0) = -3\mu(\Lambda^0) = \mu(\mathrm{p}). \tag{9}$$

For particles with $C = 1$ and belonging to sextet of SU(3), we have

$$\tfrac{3}{2}\mu(\mathrm{C}_{10}^{++}) = -\tfrac{3}{2}\mu(\mathrm{C}_{10}^{0}) = -\tfrac{3}{2}\mu(\mathrm{S}_{10}^{0}) = -\tfrac{3}{2}\mu(\mathrm{T}_{10}^{0}) = \mu(\mathrm{p}) \tag{10}$$

and

$$\mu(\mathrm{C}_{10}^{+}) = \mu(\mathrm{S}_{10}^{+}) = 0. \tag{10a}$$

For the contragradient triplet, with $C = 1$, we get

$$\tfrac{3}{2}\mu(\tilde{\mathrm{C}}_{10}^{+}) = \tfrac{3}{2}\mu(\mathrm{A}_{10}^{+}) = \tfrac{3}{2}\mu(\mathrm{A}_{10}^{0}) = \mu(\mathrm{p}). \tag{11}$$

For the triplet $C = 2$, we have

$$\tfrac{3}{2}\mu(\mathrm{X}_{u20}^{++}) = \mu(\mathrm{X}_{d20}^{+}) = \mu(\mathrm{X}_{s20}^{+}) = \mu(\mathrm{p}). \tag{12}$$

Also for the triplet-sextet transition moment in this multiplet, we find

$$\langle \Sigma^0|\mu|\Lambda^0\rangle = -\langle \mathrm{C}_{10}^{+}|\mu|\tilde{\mathrm{C}}_{10}^{+}\rangle = \langle \mathrm{S}_{10}^{+}|\mu|\mathrm{A}_{10}^{+}\rangle = \frac{1}{\sqrt{3}}\mu(\mathrm{p}). \tag{13}$$

3.1.2. $C' = 1$ and particles belonging to $\underline{10}'$-representation of U(4)
For the sextet with $C = 0$, we get

$$-3\mu(\mathrm{C}_{01}^{+}) = -3\mu(\mathrm{S}_{01}^{+}) = -\tfrac{3}{2}\mu(\mathrm{C}_{01}^{0}) = -\tfrac{3}{2}\mu(\mathrm{S}_{01}^{0}) = -\tfrac{3}{2}\mu(\mathrm{T}_{01}^{0}) = \mu(\mathrm{p}), \tag{14}$$

whereas

$$\mu(\mathrm{C}_{01}^{++}) = 0. \tag{14a}$$

For the triplets with $C = 1$, we find

$$-\tfrac{9}{2}\mu(\mathrm{X}_{d11}^{+}) = -\tfrac{9}{2}\mu(\mathrm{X}_{s11}^{+}) = \mu(\mathrm{p}) \tag{15}$$

and

$$\mu(X^{++}_{u11}) = 0. \tag{15a}$$

For the singlet with $C = 2$, we have

$$\mu(L^{++}_{21}) = 0. \tag{16}$$

3.1.3. $C' = 1$ and particles belonging to $\underline{6}'$-representation of U(4)
For the contragradient triplet with $C = 0$, we get

$$\tfrac{3}{2}\mu(\tilde{C}^{+}_{01}) = \tfrac{3}{2}\mu(A^{+}_{01}) = \tfrac{3}{2}\mu(A^{0}_{01}) = \mu(p). \tag{17}$$

Similarly for the triplet with $C = 1$, we get

$$\tfrac{3}{2}\mu(\hat{X}^{++}_{u11}) = \tfrac{3}{2}\mu(\hat{X}^{+}_{d11}) = \tfrac{3}{2}\mu(\hat{X}^{+}_{s11}) = \mu(p). \tag{18}$$

3.1.4. $C' = 2$ and particles belonging to $\underline{4}'$-representation of U(4)
For the triplet with $C = 0$, we have

$$\tfrac{3}{3}\mu(X^{++}_{u02}) = \mu(X^{+}_{d02}) = \mu(X^{+}_{s02}) = \mu(p) \tag{19}$$

and for the singlet with $C = 1$, we find

$$\tfrac{3}{2}\mu(L^{++}_{12}) = \mu(p). \tag{20}$$

3.1.5. The nonvanishing transition moments between $\underline{10}'$- and $\underline{6}'$-representations
The transition moments between the particles belonging to $\underline{10}'$ -and $\underline{6}'$-representations are given by

$$-\sqrt{3}\,\langle C^{+}_{01}|\mu|\tilde{C}^{+}_{01}\rangle = \sqrt{3}\,\langle S^{+}_{01}|\mu|A^{+}_{01}\rangle = 3\sqrt{3}\,\langle X^{++}_{u11}|\mu|\hat{X}^{++}_{u11}\rangle$$
$$= \frac{3\sqrt{3}}{4}\langle X^{+}_{d11}|\mu|\hat{X}^{+}_{d11}\rangle = \frac{3\sqrt{3}}{4}\langle X^{+}_{s11}|\mu|\hat{X}^{+}_{s11}\rangle = \mu(p). \tag{21}$$

3.2. Baryons belonging to $\underline{\underline{35}}$-representation

The magnetic moments of $\underline{\underline{35}}$-representation can be expressed by the following single formula:

$$\mu(X^*) = Q_{X^*}\mu(p), \tag{22}$$

where Q_{X^*} is the charge of the particle X^* belonging to $\underline{\underline{35}}$-representation of U(5).

3.3. Transition moments between $\underline{\underline{35}}$- and $\underline{\underline{40}}$-representations

3.3.1. Transition moments for particles with $C' = 0$
The transition magnetic moments between the decouplet and octet particles with $C = 0$ are given by

$$\langle N^{*+}|\mu|p\rangle = -\langle Y^{*+}|\mu|\Sigma^-\rangle = \langle N^{*0}|\mu|n\rangle = 2\langle Y^{*0}|\mu|\Sigma^0\rangle$$
$$= -\frac{2}{\sqrt{3}}\langle Y^{*0}|\mu|\Lambda^0\rangle = -\langle \Xi^{*0}|\mu|\Xi^0\rangle = \frac{2\sqrt{2}}{3}\mu(p). \tag{23}$$

For the particles with $C = 1$, the nonvanishing transition moments turn out to be

$$-2\langle C^{*+}_{10}|\mu|C^{+}_{10}\rangle = -2\langle S^{*+}_{10}|\mu|S^{+}_{10}\rangle = -\langle C^{*0}_{10}|\mu|C^{0}_{10}\rangle$$

$$= -\langle S^{*+}_{10}|\mu|S^{0}_{10}\rangle = -\langle T^{*0}_{10}|\mu|T^{0}_{10}\rangle = \frac{2\sqrt{2}}{3}\mu(\mathrm{p}) \tag{24a}$$

and

$$\langle C^{*+}_{10}|\mu|\tilde{C}^{+}_{10}\rangle = -\langle S^{*+}_{10}|\mu|A^{+}_{10}\rangle = \sqrt{\tfrac{2}{3}}\,\mu(\mathrm{p}). \tag{24b}$$

We get for particles with $C = 2$

$$-\langle X^{*+}_{d20}|\mu|X^{+}_{d20}\rangle = -\langle X^{*+}_{s20}|\mu|X^{+}_{s20}\rangle = \frac{2\sqrt{2}}{3}\mu(\mathrm{p}). \tag{25}$$

The results shown in Eqs. (23)–(25) have been previously obtained, but we include them for the reason of completeness and we express them in terms of the new terminology of the particle assignment.

3.3.2. Transition moment for particles with $C' = 1$

For the particles with $C = 0$, we have transition moment between $\underline{10}$- and 10′-representations of U(4)

$$\langle C^{*+}_{01}|\mu|C^{+}_{01}\rangle = \langle S^{*+}_{01}|\mu|S^{+}_{01}\rangle = 2\langle C^{*0}_{01}|\mu|C^{0}_{01}\rangle = 2\langle S^{*0}_{01}|\mu|S^{0}_{01}\rangle$$

$$= \langle T^{*0}_{01}|\mu|T^{0}_{01}\rangle = -\frac{\sqrt{2}}{3}\mu(\mathrm{p}). \tag{26}$$

For particles with $C = 1$, and belonging to $\underline{10}$- and $\underline{10}'$-representation, the transition moments are

$$\langle X^{*+}_{d11}|\mu|X^{+}_{d11}\rangle = \langle X^{*+}_{s11}|\mu|X^{+}_{s11}\rangle = -\frac{\sqrt{2}}{3}\mu(\mathrm{p}). \tag{27}$$

Similarly we obtain for nonvanishing transitions between $\underline{10}$- and $\underline{6}'$-representations, with $C = 0$

$$\langle C^{*+}_{01}|\mu|\tilde{C}^{+}_{01}\rangle = -\langle S^{*+}_{01}|\mu|A^{+}_{01}\rangle = \sqrt{\tfrac{2}{3}}\,\mu(\mathrm{p}). \tag{28}$$

Also for $C = 1$ particles, the transition moments between $\underline{10}$- and $\underline{6}'$-representations of U(4) are given by

$$\langle X^{*++}_{u11}|\mu|\hat{X}^{++}_{u11}\rangle = 4\langle X^{*+}_{d11}|\mu|\hat{X}^{+}_{d11}\rangle = 4\langle X^{*+}_{s11}|\mu|\hat{X}^{+}_{s11}\rangle = -\frac{\sqrt{2}}{3\sqrt{3}}\mu(\mathrm{p}). \tag{29}$$

3.4. Transition moments between particles with $C' = 2$

The nonvanishing transition moments between particles belonging to $\underline{4}$-representation (of $\underline{\underline{35}}$-multiplet) and $\underline{4}'$-representation (of $\underline{\underline{40}}$-multiplet) are given by

$$\langle X^{*++}_{u02}|\mu|X^{++}_{u02}\rangle = 4\langle X^{*+}_{d02}|\mu|X^{+}_{d02}\rangle = 4\langle X^{*+}_{s02}|\mu|X^{+}_{s02}\rangle = \frac{8\sqrt{2}}{9}\mu(\mathrm{p}). \tag{30}$$

For $C = 1$, we have the only nonvanishing contribution between $\underline{4}$- and $\underline{4}'$-particles, which is

$$\langle L_{12}^{*++}|\mu|L_{12}^{++}\rangle = \frac{8\sqrt{2}}{9}\,\mu(p). \tag{31}$$

In all transition moment results we find that the following relation is always satisfied

$$\langle X|\mu|Y\rangle = \langle Y|\mu|X\rangle. \tag{31a}$$

4. *Magnetic moments in an alternate model*

To accomodate the possibility that the fifth quark possesses a charge $Q = -1/3$, the scheme of baryon classification changes considerably. With f-quark having the quantum number attributed to it as mentioned in the previous paper Chl [1], Section IV, we note that all particles with $C' = 0$ retain U(4) identification and only particles with nonvanishing fancy quantum number have been listed in Table IV of reference Chl [1].

4.1. $\underline{\underline{40}}$-representation

4.1.1. Particles belonging to the 20′-representation of U(4) with $C' = 0$
The magnetic moments for the baryons with $C' = 0$ remain unchanged. Thus we can use the Eqs. (9)–(13) for the magnetic moment of particles belonging to the new classification with the same nomenclature as the C–C′ model.

4.1.2. Particles belonging to the $\underline{10}'$-representation with $C' = 1$
For the particles belonging to the $\underline{10}'$-representation of U(4) within the $\underline{\underline{40}}$-multiplet, we obtain the following results:

$$\mu(\mathbf{C}_{01}^{+}) = \mu(\mathbf{X}_{u11}^{+}) = \mu(\mathbf{L}_{21}^{+}) = \tfrac{2}{3}\mu(p) \tag{32a}$$

$$\mu(\mathbf{C}_{01}^{0}) = \mu(\mathbf{S}_{01}^{0}) = \tfrac{1}{3}\mu(p) \tag{32b}$$

and

$$\mu(\mathbf{C}_{01}^{-}) = \mu(\mathbf{S}_{01}^{-}) = \mu(\mathbf{T}_{01}^{-}) = \mu(\mathbf{X}_{s11}^{0}) = \mu(\mathbf{X}_{d11}^{0}) = \tfrac{4}{9}\mu(p). \tag{32c}$$

4.1.3. Particles within the $\underline{6}'$-representation with $C' = 1$
For the sextet belonging to U(4) with $C' = 1$, we have

$$\mu(\tilde{\mathbf{C}}_{01}^{0}) = \mu(\mathbf{A}_{01}^{0}) = \mu(\mathbf{A}_{01}^{-}) = \mu(\hat{\mathbf{X}}_{u11}^{+}) = \mu(\hat{\mathbf{X}}_{d11}^{0}) = \mu(\hat{\mathbf{X}}_{s11}^{0}) = -\tfrac{1}{3}\mu(p). \tag{33}$$

4.1.4. Particles within the $\underline{4}'$-representation with $C' = 2$
Finally for the $\underline{4}'$-representation belonging to the $\underline{\underline{40}}$-multiplet, we find

$$\mu(\mathbf{X}_{u02}^{0}) = 2\mu(\mathbf{X}_{d02}^{-}) = 2\mu(\mathbf{X}_{s02}^{-}) = \mu(\mathbf{L}_{12}^{0}) = -\tfrac{2}{3}\mu(p). \tag{34}$$

4.2. 35-representation

The magnetic moments of all particles belonging to the 35-representation of our model can also be expressed by Eq. (22). We shall have only to remember that the particle charges have changed for $C' \neq 0$ cases of 35-representation as shown in Table IV of reference ChI [1].

4.3. Transition moments

The transition moments between the particles belonging to the 35- and the 40-representations in our new model can also be easily obtained.

4.3.1. Transition magnetic moments between 20- and 20′-representations with $C' = 0$
The transition moments between 20- and 20′-representations with $C' = 0$ yield the same results as in Eqs. (23)–(25).

4.3.2. Transition moments for $C' = 1$ particles
The nonvanishing transition moments between particles belonging to the 10-representation and the 10′-representation with $C' = 1$ for both initial and final states are given by

$$\langle \mathbf{C}_{01}^{*+}|\mu|\mathbf{C}_{01}^{+}\rangle = \langle \mathbf{X}_{u11}^{*+}|\mu|\mathbf{X}_{u11}^{+}\rangle = \langle \mathbf{L}_{21}^{*+}|\mu|\mathbf{L}_{21}^{+}\rangle = -\frac{2\sqrt{3}}{3}\mu(\mathrm{p}), \tag{35a}$$

$$\begin{aligned}\langle \mathbf{C}_{01}^{*0}|\mu|\mathbf{C}_{01}^{0}\rangle &= \langle \mathbf{S}_{01}^{*0}|\mu|\mathbf{S}_{01}^{0}\rangle = \langle \mathbf{X}_{d11}^{*0}|\mu|\mathbf{X}_{d11}^{0}\rangle \\ &= \langle \mathbf{X}_{s11}^{*0}|\mu|\mathbf{X}_{s11}^{0}\rangle = -\frac{\sqrt{2}}{3}\mu(\mathrm{p}).\end{aligned} \tag{35b}$$

4.3.3. Transition moment between the 4- and 4′-representations with $C' = 2$
Finally for the magnetic moments between the particles belonging to the 4-representation of the 35-multiplet and the 4′-representation of the 40-multiplet, with $C' = 2$ for both initial and final particle states, we get

$$\langle \mathbf{X}_{u02}^{*0}|\mu|\mathbf{X}_{u02}^{0}\rangle = \langle \mathbf{L}_{12}^{*0}|\mu|\mathbf{L}_{12}^{0}\rangle = \frac{2\sqrt{2}}{9}\mu(\mathrm{p}) \tag{36a}$$

and

$$\langle \mathbf{X}_{d02}^{*-}|\mu|\mathbf{X}_{d02}^{-}\rangle = \langle \mathbf{X}_{s02}^{*-}|\mu|\mathbf{X}_{s02}^{-}\rangle = -\frac{4\sqrt{2}}{9}\mu(\mathrm{p}). \tag{36b}$$

The Eq. (32a) remains valid also in the alternate model.

5. *Concluding remarks*

We have calculated the magnetic moments of fancied baryons in the preceding sections assuming that the magnetic moment operator was to transform as $(24, 3_s)$-component of U(10). The discovery of Y reveals that such particles would be discovered eventually if Y is considered as the bound state of a new quark f and its antiparticle. This quark carries a new quantum number C'. We derived the results for two separate schemes. The first classification scheme is exactly the one which was discussed by Achiman, Kollar and Walsh. This model makes the basic assumption that the charge of the quark is $Q = 2/3$. The second alternate scheme assumes that the charge of the fancy quark is $Q = -1/3$. All the results could now be expressed in terms of the magnetic moment of the proton. The emergence of the magnetic moments of these particles only in terms of $\mu(\mathrm{p})$ is a fortunate coincidence. It happens because the particles belong to a totally symmetric representation of U(10). As mentioned before, our results for the conventional particles stay as those of U(8) results.

We are aware of the fact that the symmetry breaking would upset the results obtained here [10]. We are planning to study the effect of symmetry breaking in a separate communication.

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[9] There is an unfortunate printing mistake in CJ2. The coefficient of $\langle Y^{+0}|\mu|\Lambda^0\rangle$ should be $-2/\sqrt{3}$ rather than $-\sqrt{3}/2$.

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