MAGNETIC MOMENTS OF THE CHARMED VECTOR BOSONS IN SU(10)

BY A. L. CHOUDHURY

Department of Mathematics, Elizabeth City State University, Elizabeth City*

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The magnetic moments of the vector mesons and the transition magnetic moments of the vector-pseudoscalar mesons have been computed assuming that the magnetic moment operator transforms as the (24, 3) component of the SU(10)-symmetry and has been compared with the similar results obtained in SU(8). It has been found that for both charged and uncharged particles with non-vanishing hypercharge the values remain unchanged. However, for the uncharged mesons with $Y = 0$, $C = C' = 0$, the results differ considerably. For example the magnetic moment of ψ particle is given by $\mu(\psi) = (64/25)\mu(\varrho^0)$ in this case in contrast to the result of SU(8): $\mu(\psi) = 4\mu(\varrho^0)$.

1. Introduction

Since the discovery of J/ψ particle [1], intensive theoretical and experimental works are being carried out to determine whether or not the concept of charm has earned a permanent foothold in the domain of particle physics. As days are passing by more and more physicists are siding with the bandwagon of charm. With the discovery of more resonances it is not whether charm quantum number exists but it is a question how it exists and which model does it favor.

Considering the rise in the experimental value of $R = \dfrac{(e^+e^- \to \text{hadrons})}{(\mu^+\mu^- \to \text{hadrons})}$ although for the time being a quark model with 4-quarks [2], with usual three quarks u, s, d postulated by Gell-Mann and an additional quark c with new quantum number, charm, $C = 1$, can explain most of the new resonances, however quantitatively the question is far from being settled. In addition to that a further rise in R with higher energy raises the question, is the total number of flavor, which is now four, enough [3]? Many physicists are still of the opinion that this question is still wide open. Theoreticians are already constructing models with quarks having more than four flavors. We must not however

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

forget that in order to retain the fermion character of the baryons all the quarks have to possess color [4] as the additional characteristics. But the physicists postulate that baryons and mesons are supposed to be color singlets in the classification of the fundamental particles. We would restrict ourselves only to the question of flavor and how far they do effect the physical quantities.

Among the recent models with more flavors, the simplest but also interesting one is that proposed by Achiman, Kollar and Walsh [5] on the basis of five quarks. We are aware of the fact that the c−c′ model mentioned in their paper necessitates a pair of heavy leptons in order to remove the triangle anomaly. We are however tempted to see how such extra flavor effects other experimentally determinable quantities. In this model the particle ψ' is considered to be $f\bar{f}$ combination of a new quark f (which we would call fancy) with fancy quantum number $C' = 1$ and its antiparticle $\bar{f}$. We must mention here that the present consensus prefers ψ' to be the radially excited state of $c\bar{c}$ combination, but since we intend only to check on the models with higher flavors as the alternative, we would just ignore this apparent experimental favor for the radial mode of ψ as ψ'. There are other models where six quarks play more fundamental role. They postulate the equality of the basic quark flavors and the number of leptons. Although they are attractive, however they are equally hypothetical as the model proposed by Achiman et al. [5]. We would restrict ourselves only to their five quark model, particularly the one which they referred as the c−c′ assignment.

Recently the author [6] has calculated the magnetic moments of the vector mesons and the transition moments between the pseudoscalar and the vector mesons, by assuming that the magnetic moment operator transforms as (15,3)-representation of SU(8) which contains SU(4) × SU(2) as subgroup [7]. The motivation of this paper is to extend the symmetry to SU(10), which contains SU(5) ×SU(2) as a subgroup. The internal symmetry is assigned through SU(5) and the spin indices are expressed through SU(2). The mesons are classified in the 99-representation of SU(10). Both ψ and ψ' are supposed to belong to this representation. Assuming now that the magnetic moment operator to transform as (24,3) representation of SU(5) × SU(2) ($\subset$ SU(10)), we derive the ratios of the magnetic moments of the mesons. We have assigned the quark contents of the mesons to be same in both models and concluded that the results of the $Y = 0$ and $C = C' = 0$ mesons are different in two models. We are tempted to conclude that this difference in the magnetic moment values should be one of the many criterions to decide, which model is experimentally favored.

In Section 2 we briefly explain the SU(5) and the c−c′ classification of Achiman et al. [5] and introduce tensors to represent particles in the SU(10)-symmetry. In Section 3 we compute the magnetic moments of the vector mesons and the transition moments between vector and pseudoscalar mesons. We discuss the results in Section 4.

2. *SU(10)-classification*

We assume that the particles are classified without introducing intrinsic spin by SU(5)-symmetry. In addition to the usual 4-quarks of SU(4), we introduce following Achiman et al. [5] a new quark with charge $Q = 2/3$, $Y = 2/3$, $C = 0$ and $C' = 1$ where C'

is a new quantum number, say, fancy. All other quarks have $C' = 0$. The particles now satisfy the extended Gell-Mann–Nishijima formula

$$Q = I_3 + \frac{Y}{2} + C + C'. \tag{1}$$

The mesons then belong to the **24**-representation of SU(5) and in terms of SU(3) $\times U_1(1) \times U_2(1)$, where the first $U_1(1)$ symmetry belongs to the charm quantum number and $U_2(1)$ is associated with the fancy quantum number, we find

$$\begin{aligned} 24 &= (1+8, 0, 0)+(\bar{3}, 1, 0)+(\bar{3}, 0, 1)+(3, -1, 0) \\ &\quad +(3, 0, -1)+(1, 1, -1)+(1, -1, 1)+(1, 0, 0). \end{aligned} \tag{2}$$

In equation (2) the symbol (m, n, q) means that it belongs to the m-th representation of SU(3) with $C = n$ and $C' = q$. The new particles in $(\bar{3}, 0, 1)$ and $(3, 0, -1)$ are indicated by the same symbols as their counterparts in $(\bar{3}, 1, 0)$ and $(3, -1, 0)$ respectively with an additional suffix "f". The particle $(1, 1, -1)$ is denoted by $\tilde{C}^0$ and $(1, -1, 1)$ by C^0.

The mesons in SU(10)-representation are assumed as usual to be made up of quark and antiquark combination. In terms of SU(5) × SU(2) characterisation, this can be expressed as

$$10 \times \overline{10} = \underline{1} + \underline{99}; \quad \underline{99} = (1+24, 3)+(24, 1) \tag{3}$$

where (m, n) means m-th representation of SU(5) and n-th representation of SU(2). The $\underline{99}$-representation is associated with Young's tableau [211111111]. We can represent the particles in $\underline{99}$-representation with a tensor $B_{\{ABCDEFGHI\}J}$ where $A = (\alpha, a)$, $B = (\beta, b)$ etc. The greek alphabet is used to indicate SU(5) indices and the latin one for SU(2). Hence α-s run from 1 through 5 and a-s from 1 through 2. The tensor B is antisymmetric with respect to the interchange of the indices within the curly bracket. Using (3) we can express B as

$$B_{\{ABCDEFGHI\}J} = \frac{1}{\sqrt{(9!)}} \varepsilon_{ABCDEFGHIK} \mathfrak{B}^K{}_J, \tag{4}$$

where $\varepsilon_{ABCDEFGHIK}$ is the Levi-Civita tensor in ten dimensions. For $\mathfrak{B}^A{}_B$ we put

$$\mathfrak{B}^A{}_B = V^\alpha{}_\beta \chi_{ab} + \frac{1}{\sqrt{2}} P^\alpha{}_\beta \varepsilon_{ab} \chi_0, \tag{5}$$

where $V^\alpha{}_\beta$ and $P^\alpha{}_\beta$ are defined subsequently. The vector mesons are given by

$$[V^\alpha{}_\beta] = \begin{bmatrix} V^1{}_1 & \varrho^+ & K^{*+} & \tilde{D}^{*0} & \tilde{D}^{*0}_f \\ \varrho^- & V^2{}_2 & K^{*0} & D^{*-} & D^{*-}_f \\ K^{*-} & \overline{K}^{*0} & V^3{}_3 & F^{*-} & F^{*-}_f \\ D^{*0} & D^{*+} & F^{*+} & V^4{}_4 & \tilde{C}^{*0} \\ D^{*0}_f & D^{*+}_f & F^{*+}_f & C^{*0} & V^5{}_5 \end{bmatrix}, \tag{6}$$

where

$$V^1{}_1 = \frac{3\omega}{5\sqrt{2}} + \frac{\varrho^0}{\sqrt{2}} - \tfrac{1}{5}(\phi+\psi+\psi'), \tag{6a}$$

$$V^2{}_2 = \frac{3\omega}{5\sqrt{2}} - \frac{\varrho^0}{\sqrt{2}} - \tfrac{1}{5}(\phi+\psi+\psi'), \tag{6b}$$

$$V^3{}_3 = -\frac{\sqrt{2}\,\omega}{5} + \tfrac{1}{5}(4\phi-\psi-\psi'), \tag{6c}$$

$$V^4{}_4 = \tfrac{1}{5}(-\sqrt{2}\,\omega-\phi+4\psi-\psi'), \tag{6d}$$

$$V^5{}_5 = \tfrac{1}{5}(-\sqrt{2}\,\omega-\phi-\psi+4\psi'). \tag{6e}$$

In assigning the proper quantum numbers we have retained the usual meaning of the $\varrho^0 = \frac{1}{\sqrt{2}}(u\bar{u}-d\bar{d})$, $\phi = s\bar{s}$ and $\psi = c\bar{c}$ of SU(4) and included the ψ'-particle as $\psi' = f\bar{f}$. We have also required that $V^\alpha{}_\beta$ must be traceless.

The pseudoscalar mesons are given by

$$[P^\alpha{}_\beta] = \begin{bmatrix} P^1{}_1 & \pi^+ & K^+ & \tilde{D}^0 & \tilde{D}^0_f \\ \pi^- & P^2{}_2 & K^0 & D^- & D^-_f \\ K^- & \overline{K}^0 & P^3{}_3 & F^- & F^-_f \\ D^0 & D^+ & F^+ & P^4{}_4 & \tilde{C}^0 \\ D^0_f & D^+_f & F^+_f & C^0 & P^5{}_5 \end{bmatrix}. \tag{7}$$

In equation (7) we have set

$$P^1{}_1 = \frac{\pi^0}{\sqrt{2}} + \frac{\eta}{\sqrt{6}} + \frac{\eta'}{2} + \frac{\eta_c}{2\sqrt{3}} - \frac{\eta''}{\sqrt{5}}, \tag{7a}$$

$$P^2{}_2 = -\frac{\pi^0}{\sqrt{2}} + \frac{\eta}{\sqrt{6}} + \frac{\eta'}{2} + \frac{\eta_c}{2\sqrt{3}} - \frac{\eta''}{\sqrt{5}}, \tag{7b}$$

$$P^3{}_3 = -\frac{2\eta}{\sqrt{6}} + \frac{\eta'}{2} + \frac{\eta_c}{2\sqrt{3}} - \frac{\eta''}{\sqrt{5}}, \tag{7c}$$

$$P^4{}_4 = \frac{\eta'}{2} - \frac{\sqrt{3}\,\eta_c}{2} - \frac{\eta''}{\sqrt{5}}, \tag{7d}$$

$$P^5{}_5 = -2\eta' + \frac{4\eta''}{\sqrt{5}}. \tag{7e}$$

The assignment of the tensor components has been done keeping in mind that the definition of the usual particles attributed in the SU(4)-model has been kept intact. Thus $\varrho^0 = \frac{1}{\sqrt{2}}(u\bar{u}-d\bar{d})$, $\eta = \frac{1}{\sqrt{6}}(u\bar{u}+d\bar{d}-2s\bar{s})$, $\eta_c = \frac{1}{\sqrt{12}}(u\bar{u}+d\bar{d}+s\bar{s}-3c\bar{c})$ and $\eta' = \frac{1}{2}(u\bar{u}+d\bar{d}+s\bar{s}+c\bar{c})$. We have introduced another meson $\eta'' = \frac{1}{\sqrt{5}}(u\bar{u}+d\bar{d}+s\bar{s}+c\bar{c}+f\bar{f})$. Again $P^\alpha{}_\alpha = 0$.

In expression (5) we have also used the intrinsic spin function χ_{ab} to represent spin one particles. They are given by

$$\chi_{11} = u_1, \quad \chi_{12} = \chi_{21} = \frac{1}{\sqrt{2}} u_0, \quad \chi_{22} = u_{-1}. \tag{8}$$

The u's are normalized to one. χ_0 stands for a state of spin zero particle and also normalized to one.

3. *Magnetic moments*

The most general current we can construct out of B and $\bar{B}$ can be written as

$$J^{A'}{}_A = \mu_1 \bar{\mathfrak{B}}_B{}^{A'} \mathfrak{B}^B{}_A + \mu_2 \bar{\mathfrak{B}}_A{}^B \mathfrak{B}^{A'}{}_B + g_0 \delta^{A'}{}_A \bar{\mathfrak{B}}_B{}^C \mathfrak{B}^B{}_C. \tag{9}$$

The tracelessness condition yields

$$\mu_1 + \mu_2 = 10\, g_0. \tag{10}$$

Following Bég, Lee and Pais, we assume that the magnetic moment in the low frequency limit transforms as (24, 3) component of a tensor and M can be expressed as

$$M = \mu_0 J^{A'}{}_A \vec{\sigma}^\alpha{}_{\alpha'} \cdot \vec{n} Q^\alpha{}_{\alpha'}. \tag{11}$$

The meaning of $\vec{n}$ is as usual (see for example reference [6]). The operator Q is the diagonal charge operator: $Q^\alpha{}_{\alpha'} = q_{\alpha'} \delta^\alpha{}_{\alpha'}$ with $q_1 = q_4 = q_5 = 2/3$ and $q_2 = q_3 = -1/3$.

Substituting (9) in (11) we get

$$M = M(\bar{V}V) + M(\bar{P}P) + M(\bar{V}P) + M(\bar{P}V), \tag{12}$$

where

$$M(\bar{V}V) = \mu_0 \vec{n} \cdot \langle \chi \vec{\sigma} \chi \rangle_1 [\mu_x \{\bar{V} V_F\}^{\alpha'}{}_\alpha + \mu_y \{\bar{V} V_D\}^{\alpha'}{}_\alpha] Q^\alpha{}_{\alpha'}, \tag{13}$$

$$M(\bar{P}P) = 0, \tag{14}$$

$$M(\bar{V}P) = \frac{1}{\sqrt{2}} \mu_0 \vec{n} \cdot \langle \chi_1 \vec{\sigma} \chi_0 \rangle [\mu_x \{\bar{V} P_F\}^{\alpha'}{}_\alpha + \mu_y \{\bar{V} P_D\}^{\alpha'}{}_\alpha] Q^\alpha{}_{\alpha'}, \tag{15}$$

$$M(\bar{P}V) = \frac{1}{\sqrt{2}} \mu_0 \vec{n} \cdot \langle \chi_0 \vec{\sigma} \chi_1 \rangle [\mu_x \{\bar{P} V_F\}^{\alpha'}{}_\alpha + \mu_y \{\bar{P} V_D\}^{\alpha'}{}_\alpha] Q^\alpha{}_{\alpha'}. \tag{16}$$

In the expressions (13) through (16) the abbreviation $\{\bar{V}V_F\}^{\alpha'}{}_{\alpha}$ stands for the F-current given by

$$\{\bar{V}V_F\}^{\alpha'}{}_{\alpha} = \bar{V}_{\beta}{}^{\alpha'}V^{\beta}{}_{\alpha} - \bar{V}_{\alpha}{}^{\beta}V^{\alpha'}{}_{\beta} \tag{17}$$

and $\{\bar{V}V_D\}^{\alpha'}{}_{\alpha}$ for the D-current without the trace term as shown below

$$\{\bar{V}V_D\}^{\alpha'}{}_{\alpha} = \bar{V}_{\beta}{}^{\alpha'}V^{\beta}{}_{\alpha} + \bar{V}_{\alpha}{}^{\beta}V^{\alpha}{}_{\beta}. \tag{18}$$

We have also used the abbreviations

$$\mu_x = \tfrac{1}{2}(\mu_1 - \mu_2); \qquad \mu_y = \tfrac{1}{2}(\mu_1 + \mu_2), \tag{19}$$

$$\langle \bar{\chi}\vec{\sigma}\chi\rangle_1 = \bar{\chi}^{ab}\vec{\sigma}_a{}^d\chi_{bd}, \tag{20}$$

$$\langle \bar{\chi}_1\vec{\sigma}\chi_0\rangle = \bar{\chi}^{ab}\vec{\sigma}_a{}^d\varepsilon_{bd}\chi_0, \tag{21}$$

and

$$\langle \bar{\chi}_0\vec{\sigma}\chi\rangle_1 = \bar{\chi}_0\varepsilon^{ab}\vec{\sigma}_b{}^d\chi_{ad}. \tag{22}$$

Now defining $\mu(X) = \langle X; J = 1, J_z = 1|M|X; J = 1, J_z = 1\rangle$ we find

$$\tfrac{25}{21}\,\mu(\omega) = \mu(\varrho^0) = -\tfrac{25}{22}\,\mu(\phi) = \tfrac{25}{68}\,\mu(\psi) = \tfrac{25}{68}\,\mu(\psi') = -\tfrac{1}{2}\,\mu(K^{*0})$$

$$= -\tfrac{1}{2}\,\mu(\bar{K}^{*0}) = \tfrac{1}{4}\,\mu(D^{*0}) = \tfrac{1}{4}\,\mu(\tilde{C}^{*0}) = \tfrac{1}{4}\,\mu(D_f^{*0}) = \tfrac{1}{4}\,\mu(C^{*0}) = \tfrac{1}{3}\,\mu_0 n_3\mu_y \tag{23}$$

$$\mu(\varrho^+) = \mu(D^{*+}) = \mu(F^{*+}) = \mu(D_f^{*+}) = \mu(F_f^{*+}) = \tfrac{1}{3}\,\mu_0 n_3[-3\mu_x + \mu_y] \tag{24}$$

and

$$\mu(\varrho^-) = \mu(D^{*-}) = \mu(D_f^{*-}) = \mu(K^{*-}) = \tfrac{1}{3}\,\mu_0 n_3[3\mu_x + \mu_y]. \tag{25}$$

The $V-V$ transitions are defined as $\langle X|\mu|Y\rangle = \langle X; J = 1, J_z = 1|M|Y; J = 1, J_z = 1\rangle$ and the results are tabulated in Table I. In the table we have also requoted the moments of the individual particles defined previously as $\langle X|\mu|X\rangle = \mu(X)$. All the magnetic moments there are given in the units of $\mu(\varrho^0)$. For example, the transition moment between ψ' and ϕ has to be read as $\langle\phi|\mu|\psi'\rangle = -\frac{2}{25}\mu(\varrho^0)$.

For the $P-V$ transition, we define $\langle X|\mu|V\rangle = \langle Y|\mu|X\rangle = \langle X; J = 1, J_z = 0|M|Y; J = 0, J_z = 0\rangle$ where X is a vector and Y is a pseudoscalar meson. Using equation (15) we find in the units of $\mu(\varrho^0)$ the transition moments of the neutral particles with $Y = 0$, $I_z = 0$, $C = C' = 0$ as shown in the Table II. Thus for example the moment between η'' and ψ' is given by $\langle\psi'|\mu|\eta''\rangle = -\dfrac{72\sqrt{2}}{5\sqrt{5}}\,\mu(\varrho^0)$.

For the neutral particles with $Y \neq 0$, the transition moments are given by

$$-\langle D^{*0}|\mu|D^0\rangle = -\langle D_f^{*0}|\mu|D_f^0\rangle = 2\langle\bar{K}^{*0}|\mu|\bar{K}^0\rangle = 2\langle K^{*0}|\mu|K^0\rangle = -\langle\tilde{D}^{*0}|\mu|\tilde{D}^0\rangle$$

$$= -\langle C^{*0}|\mu|C^0\rangle = -\langle\tilde{D}_f^{*0}|\mu|\tilde{D}_f^0\rangle = -\langle\tilde{C}^{*0}|\mu|\tilde{C}^0\rangle = 4\sqrt{2}\,\mu(\varrho^0). \tag{26}$$

TABLE I

Transition magnetic moments between the uncharged vector bosons with $Y = C = C' = 0$ in units of $\mu(\varrho^0)$

	ω	ϱ^0	ϕ	ψ	ψ'
ω	$\frac{21}{25}$	$\frac{9}{5}$	$\frac{13\sqrt{3}}{25}$	$-\frac{17\sqrt{3}}{25}$	$-\frac{17\sqrt{3}}{25}$
ϱ^0	$\frac{9}{5}$	1	$-\frac{3\sqrt{2}}{5}$	$-\frac{3\sqrt{2}}{5}$	$-\frac{3\sqrt{2}}{5}$
ϕ	$\frac{13\sqrt{3}}{25}$	$-\frac{3\sqrt{2}}{5}$	$-\frac{22}{25}$	$-\frac{2}{25}$	$-\frac{2}{25}$
ψ	$-\frac{17\sqrt{3}}{25}$	$-\frac{3\sqrt{2}}{5}$	$-\frac{2}{25}$	$\frac{68}{25}$	$-\frac{32}{25}$
ψ'	$-\frac{17\sqrt{3}}{25}$	$-\frac{3\sqrt{2}}{5}$	$-\frac{2}{25}$	$-\frac{32}{25}$	$\frac{68}{25}$

TABLE II

Transition magnetic moments between the uncharged vector and pseudoscalar mesons with $Y = C = C' = 0$ in units of $\mu(\varrho^0)$

	ω	ϱ^0	ϕ	ψ	ψ'
π^0	$-\frac{9\sqrt{2}}{5}$	$-\frac{3\sqrt{2}}{8}$	$\frac{6}{5}$	$\frac{6}{5}$	$\frac{6}{5}$
η	$\frac{2}{5\sqrt{3}}$	$-\sqrt{6}$	$\frac{6\sqrt{3}}{5}$	$\frac{2\sqrt{3}}{5}$	$\frac{2\sqrt{3}}{5}$
η'	$-\frac{17}{5}$	-3	$\frac{\sqrt{2}}{5}$	$-\frac{16\sqrt{3}}{5}$	$\frac{34\sqrt{2}}{5}$
η_c	$-\frac{17}{5\sqrt{3}}$	$-\sqrt{3}$	$\frac{\sqrt{6}}{5}$	$\frac{8\sqrt{6}}{5}$	$-\frac{2\sqrt{6}}{5}$
η''	$\frac{34}{5\sqrt{5}}$	$\frac{6}{\sqrt{5}}$	$\frac{2\sqrt{2}}{5\sqrt{5}}$	$\frac{28\sqrt{2}}{5\sqrt{5}}$	$-\frac{72\sqrt{2}}{5\sqrt{5}}$

The transition moments between the negatively charged particles are as follows:

$$\langle \varrho^- | \mu | \pi^- \rangle = \langle K^{*-} | \mu | K^- \rangle = \langle D^{*-} | \mu | D^- \rangle = \langle F^{*-} | \mu | F^- \rangle$$
$$= \langle D_f^{*-} | \mu | D_f^- \rangle = \langle F_f^{*-} | \mu | F_f^- \rangle = -2\mu(\varrho^-). \qquad (27)$$

Similarly for all positively charged particles the $V-P$ transition magnetic moments are given by

$$\langle \varrho^+|\mu|\pi^+\rangle = \langle D^{*+}|\mu|D^+\rangle = \langle K^{*+}|\mu|K^+\rangle = \langle F^{*+}|\mu|F^+\rangle$$
$$= \langle F_f^{*+}|\mu|F_f^+\rangle = -\sqrt{2}\,\mu(\varrho^+). \tag{28}$$

In all above transition moments we must stress finally that the condition $\langle X|\mu|Y\rangle = \langle Y|\mu|X\rangle$ is satisfied in every case.

5. *Concluding remarks*

Extending SU(8) to SU(10) symmetry, we have derived magnetic moments in terms of three parameters $\mu(\varrho^0)$, $\mu(\varrho^+)$ and $\mu(\varrho^-)$. The results obtained do not change the magnetic moments of the vector mesons with $Y \neq 0$ that have been obtained by the author in a previous paper [6] for SU(8) symmetry. However the magnetic moments for the vector particles with $Y = I_z = C = C' = 0$ the results are essentially different, although we have retained the quark constitution of the similar particles in both SU(8) and SU(10) the same. The transition magnetic moments similarly stay unchanged between particles with $Y \neq 0$. But the moments between the uncharged particles with $Y = C = C' = 0$ changes essentially. Thus for example, in case of the vector meson ψ the result $\mu(\psi) = 4\mu(\varrho^0)$ as quoted in [6] changes into $\mu(\psi) = \frac{68}{25}\,\mu(\varrho^0)$ as we find from equation (23) or Table I. Similarly the transition moment between π^0 and ψ is given by $\langle \pi^0|\mu|\psi\rangle = 0$ in SU(8), whereas in SU(10) we get from Table II, $\langle \pi^0|\mu|\psi\rangle = \frac{6}{5}\mu(\varrho^0)$. However we must not forget to mention that if the magnetic moment of ϱ^0 comes out to be zero, then there would be no way to choose between the two symmetries because the moments turn out to be identical in both symmetries. If on the other hand $\mu(\varrho^0) \neq 0$, the experimental ratio $\mu(\psi)/\mu(\varrho^0)$ may indicate the type of symmetry we have to choose from out of different alternatives. Hence we find it important to measure the ratio of the magnetic moments of ψ and ϱ^0 which eventually help us to fix the number of flavors a symmetry has to have. In the above consideration we are assuming that any other type of symmetry breaking which has any influence on the magnetic moment operator would be essentially small effect, which might not be always true. We are trying to study the impact of such symmetry breaking effects separately as an extension of this work.

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