## ELECTROMAGNETIC PROPERTIES OF MESONS IN SU(6) SYMMETRY

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In the present note we investigate the relations between the magnetic moments of charged vector mesons and the amplitudes of the decay V → P + γ within the framework of SU(6) symmetry[1] (V - vector meson belonging to a unitary octet or singlet, P - pseudoscalar meson).

The vector and pseudoscalar mesons are described in SU(6) symmetry by a second-rank tensor $\Phi^A_B$(A, B = 1, ..., 6) which has the following form in terms of the meson wave functions[2]:

$$\Phi^A_B \equiv \Phi^{i,\alpha}_{j,\beta} = \frac{1}{\sqrt{2}}\,[\delta^i_j f^\alpha_\beta + (\sigma)^i_j (V^\alpha_\beta + \frac{1}{\sqrt{3}}\,\delta^\alpha_\beta V_0)] \qquad (1)$$

where i, j = 1, 2 are the spin indices, α, β = 1, 2, 3 are unitary indices, $f^\alpha_\beta$ is the wave function of the octed of pseudoscalar mesons, $V^\alpha_\beta$ is the wave function of the octed of vector mesons, and $V_0$ is the wave function of the vector singlet.

If the electromagnetic meson current is a component of an SU(6) representation of dimensionality $\underline{35}$, corresponding to a triplet (inasmuch as we are dealing here with magnetic moments or magnetic transitions) relative to the spin subgroup SU(2) and the component $T^1_1$ of the octet relative to the subgroup SU(3), the we can obtain for the current

$$I^{A'}_A \equiv I^{i'\alpha'}_{i\alpha} = a(\bar\Phi^{i',\alpha'}_{j,\beta}\Phi^{j,\beta}_{i,\alpha} + \bar\Phi^{j,\beta}_{i,\alpha}\Phi^{i',\alpha'}_{j,\beta} - \frac{1}{3}\delta^{i'}_i\delta^{\alpha'}_\alpha\Phi^{r,\gamma}_{j,\beta}\bar\Phi^{j,\beta}_{r,\gamma}) + b(\bar\Phi^{i',\alpha'}_{j,\beta}\Phi^{j,\beta}_{i,\alpha} - \Phi^{j,\beta}_{i,\alpha}\bar\Phi^{i'\alpha'}_{j,\beta}) \qquad (2)$$

The fact that the current is determined by two parameters follows immediately from the resolution of $\underline{35} \otimes \underline{35}$ into the irreducible SU(6) representations: $\underline{35} \times \underline{35} = 1 + \underline{35} + \underline{35} + \underline{189} + \underline{280} + \underline{280^*} + \underline{405}$.

According to the invariance against charge conjugation, the magnetic moments of neutral vector mesons are equal to zero, and for this reason we must put b = 0 in (2). Substituting in (2) the expression (1) for $\Phi^A_B$, we obtain the following expression for the current responsible for the magnetic moments and the magnetic transitions:

$$I^{A'}_A = a\,{}^{i'}_{i}[(f^{\alpha'}_\beta Q^\beta_\alpha + f^\beta_\alpha Q^{\alpha'}_\beta) + (Q^{\alpha'}_\beta f^\beta_\alpha + Q^\beta_\alpha f^{\alpha'}_\beta)] + ia(\sigma_r)^{i'}_i\epsilon_{pqz}[(Q_p)^{\alpha'}_\beta(Q_q)^\beta_\alpha - (Q_p)^\beta_\alpha(Q_q)^{\alpha'}_\beta] \qquad (3)$$

where

$$Q^\alpha_\beta = V^\alpha_\beta + \frac{1}{\sqrt{3}}\delta^\alpha_\beta V_0$$

In (3) the term proportional to $(\sigma)^{i'}{}_i$ describes magnetic transitions of the type V → P + γ, while the term proportional to $(\sigma_r)^{i'}{}_i$ corresponds to the magnetic moments of vector mesons, with all these quantities determined by one parameter.

From (3) we obtain the following relations for the amplitudes of the decays V → P + γ:

$$g(\rho^- \to \pi^- \gamma) = g(\rho^+ \to \pi^+ \gamma) = g(K^{*-} \to K^- \gamma) = g(K^{*+} \to K^+ \gamma) = -\frac{1}{2}g(K^{*0} \to K^0 \gamma) = -\frac{1}{2}g(\bar K^{*0} \to \bar K^0 \gamma) =$$

$$= g(\rho^0 \to \pi^0\gamma) = \frac{1}{\sqrt{3}} g(\rho^0 \to \eta\gamma) = -g(\omega_8 \to \eta\gamma) = \frac{1}{\sqrt{3}} g(\omega_8 \to \pi^0\gamma) = \frac{1}{\sqrt{2}} g(\omega_1 \to \eta\gamma) = \frac{1}{\sqrt{6}} g(\omega_1 \to \pi\gamma) = a \tag{4}$$

where $\omega_8$ and $\omega_1$ are isotopic singlets of the unitary octed and singlet.

Relations (4) contain predictions that follow from charge symmetry and SU(3) unitary symmetry [3], and also several consequences which appear only in SU(6) symmetry. In particular, if we go over from $\omega_8$ and $\omega_1$ to the physical particles $\omega$ and $\varphi$, putting cos $= \sqrt{2/3}$ and sin $= \sqrt{1/3}$, we obtain

$$g(\varphi \to \pi^0\gamma) = 0 \tag{5a}$$

$$\frac{1}{3} g(\omega \to \pi^0\gamma) = g(\varphi \to \eta\gamma) = g(\omega \to \eta\gamma) = a \tag{5b}$$

It follows from (5a) that the decay $\varphi \to \pi^0 + \gamma$ is forbidden in natural fashion in SU(6) symmetry, in good agreement with the experimental data [5]. In SU(3) it was necessary to introduce the forbiddenness from the outside. Then, according to the  -dominating model for vector meson decay [6], Eq. (5a) leads to forbiddenness of the decays $\varphi \to 3\pi$ and $\varphi \to \rho + \pi$, which is also in good agreement with data on $\varphi$-meson decay.

Finally, for the magnetic moments of the charged vector mesons we have the relations

$$\mu(\rho^+) = -\mu(\rho^-) = \mu(K^{*+}) = -\mu(K^{*-}) = 3a \tag{6}$$

Using a value of 1 MeV for the width of the $\omega \to \pi^0 + \gamma$ decay [7], we obtain for the magnetic moment of the $\rho^+$ meson the following value

$$\mu(\rho^+) = \pm 3.2 \text{ mesic magnetons.} \tag{7}$$

The sign of the magnetic moment could be determined in principle from experiments on photoproduction of charged vector mesons on protons, or from experiments on the formation of a pair of mesons in colliding ($e^+e^-$) beams.

[1] F. Gursey and L. A. Radicati, Phys. Rev. Lett. 13, 173 (1964); A. Pais, ibid 13, 175 (1964); Gursey, Pais, and Radicat, ibid 13, 239 (1964)

[2] B. Sakita, Phys Rev. 136, B1756 (1964).

[3] S. L. Glashow, Phys. Rev. Lett, II, 49 (1963).

[4] T. K. Kuo and T. Yao, Phys. Rev. Lett. 13, 415 (1964).

[5] Schlein, Slater, Smith, Stork, and Ticho, Phys. Rev. Lett. 10, 368 (1963); Connoly, Hart, Lai, London, Moneti, Rau, Samios, Skillicorn, Yamamoto, Goldberg, Gundzik, Leitner, and Lichtman, ibid 10, 371 (1963); Lee, Moebs, Rose, Sinclair, and Van der Velde, ibid II, 508 (1963).

[6] Gell-Mann, Sharp, and Wagner, Phys. Rev. Lett. 8, 261 (1962).

[7] Gelfand, Miller, Nussbaum, Ratau, Schultz, Steinberger, Tan, Kirsch, and Plano, Proc. of Sienna Intern. Conf. on Elementary Particles, v. I, p. 293.