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E.A.Ivanov

RADIATIVE DECAYS OF VECTOR MESONS AND ω-φ MIXING

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1. Recently radiative widths $\rho^0 \to \pi^0\gamma$ and $K_0^* \to K_0\gamma$

$$\Gamma(\rho^0 \to \pi^0\gamma) = 35 \pm 10 \text{ keV}, \quad /1/ \tag{1}$$

$$\Gamma(K_0^* \to K_0\gamma) = 75 \pm 35 \text{ keV} \quad /2/ \tag{2}$$

have been measured. Their ratio agrees with SU(3)-prediction,[2] but widths themselves are $\sim$ 3 times lower than one could expect from the simplest assumptions [3,4].

(a) The effective $VP\gamma$ Lagrangian transforms as an octet;

(b) The Lagrangian is a U-spin scalar;

(c) The system ω-φ is described by the "mass-mixing" model [5].

We argue that SU(3)-symmetry itself (i.e., requirements (a), (b)) does not contradict data (1),(2). For satisfactory description of the latter it is sufficient to use the "current-mixing" model [6] of the SU(3)-breaking instead of the "mass-mixing" one. Assumption (c) can be left unaffected only if both natural assumptions (a), (b) are given up, that seems unreasonable.

2. Assumptions (a),(b),(c) result in the sum rules [3,4]

$$g_{\rho^0\pi^0} = -\frac{1}{2} g_{K_0^*K_0} = g_{K_+^*K_+}, \tag{3}$$

$$g_{\rho^0\pi^0} = \frac{1}{\sqrt{3}}\left(g_{\varphi\pi^0}\cos\theta_V - g_{\omega\pi^0}\sin\theta_V\right)_{(\theta_V=39^\circ)}, \tag{4}$$

where g_{VP} are the phenomenological $V \to P\gamma$ decay constants

$$\Gamma(V \to P\gamma) = \frac{\alpha}{24}\, g^2_{VP}\, m^3_V \left(1 - \frac{m^2_P}{m^2_V}\right)^3 .$$

Relations (3) agree with observable values:

$$|g_{\rho^0\pi^0}| \simeq 0.52 \pm 0.07\ GeV^{-1}\ /1/ ;\quad |g_{K^{*}_0 K_0}| = 1.03 \pm 0.25\ GeV^{-1}\ /2/ \qquad (5)$$

and with upper limit /7/

$$|g_{K^{*}_+ K_+}| < 1.12\ GeV^{-1} . \qquad (6)$$

At the same time, relation (4) is not satisfied by data. With experimental values $|g_{\varphi\pi^0}| = 0.14 \pm 0.03\ GeV^{-1}$ /8/ $|g_{\omega\pi^0}| = 2.50 \pm 0.12\ GeV^{-1}$ /7/ as input it predicts:

$$|g_{\rho^0\pi^0}| = \begin{cases} 1.02 \pm 0.05\ GeV^{-1} & \beta \equiv sgn\, g_{\omega\pi^0}/g_{\varphi\pi^0} < 0 \\ 0.80 \pm 0.05\ GeV^{-1} & \beta > 0 \end{cases}$$

that is 1.5-2 times the experimental value of constant $g_{\rho^0\pi^0}$.

To remove this difficulty one needs to relax the set of initial assumptions or to modify them.

3. The "mass-mixing" model is the simplest $\omega - \varphi$ mixing scheme. Just this model provides the best description of leptonic decays $\rho^0, \omega, \varphi \to \ell^+\ell^-$. Therefore it would not be desirable to affect assumption (c).

Assumptions (b),(c) together suggest the relation

$$g_{\rho^0\pi^0} - g_{K^{*}_0 K_0} = \sqrt{3}\left(g_{\varphi\pi^0} \cos\theta_V - g_{\omega\pi^0} \sin\theta_V\right) \qquad (7)$$

which disagrees with the data for any signs of constants $g_{\rho^0\pi^0}$, $g_{\varphi\pi^0}$. Thus, by giving up only assumption (a) x) one improves nothing.

If the U-spin invariance is broken but assumptions (a),(c) still hold the following sum rules

$$g_{\rho^0\pi^0} + 2 g_{K^{*}_0 K_0} = \sqrt{3}\left(g_{\omega\pi^0} \sin\theta_V - g_{\varphi\pi^0} \cos\theta_V\right) , \qquad (8)$$

$$g_{K^{*}_+ K_+} = - g_{\rho^0\pi^0} - g_{K^{*}_0 K_0} \qquad (9)$$

must take place. For $sgn\, g_{K^{*}_0 K_0}/g_{\rho^0\pi^0} < 0$ relation (8) does not agree with data. For $sgn\, g_{K^{*}_0 K_0}/g_{\rho^0\pi^0} > 0$ the agreement can be achieved, however, in this case relation (9) gives $|g_{K^{*}_+ K_+}| = 1.55\ GeV^{-1}$ that contradicts inequality (6).

Thus, in the case of the "mass-mixing" model rates (1),(2) agree neither with assumption (a) nor with assumption (b). To abandon these natural assumptions means to lose the predictive power of SU(3)-symmetry for $V \to P\gamma$ decays, that seems unsatisfactory. Therefore it is natural to choose another scheme of ω-φ mixing.

4. The "current-mixing" model /6/ implies: /4/

$$g_{\rho^0\pi^0} = -\frac{1}{2}\frac{m_\rho}{m_{K^*}}\, g_{K^{*}_0 K_0} = \frac{m_\rho}{m_{K^*}}\, g_{K^{*}_+ K_+} , \qquad (10)$$

$$g_{\rho^0\pi^0} = \frac{1}{\sqrt{3}}\left(\frac{m_\rho}{m_\varphi}\, g_{\varphi\pi^0} \cos\theta_V - \frac{m_\rho}{m_\omega}\, g_{\omega\pi^0} \sin\theta_V\right)_{(\theta_V = 26^\circ)} . \qquad (11)$$

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x) For instance, (a) may be incorrect if the electromagnetic current of hadrons contains a SU(3) invariant piece.

Relations (10) are consistent with data. Sum rule (11), in contrast to (3), gives

$$|g_{\rho\pi^0}| = \begin{cases} 0.67 \pm 0.04\ GeV^{-1} & \beta < 0 \\ 0.57 \pm 0.04\ GeV^{-1} & \beta > 0 \end{cases} \qquad (12)$$

The lower prediction agrees very well with experimental value (5a).

The decays $V \to \eta\gamma$ and $\eta_S \to V\gamma$ (where η_S denotes the ninth pseudoscalar meson, i.e., η' (958) or E(1416)) also can be described in the "current-mixing" model without contradiction with existing experimental data [x)].

The conclusion is that the present experimental data on decays $V \to P\gamma$ (and $P \to V\gamma$) can be interpreted within the framework of assumptions (a),(b) and "current-mixing" model. It is the indication in favour just of this scheme of ω-φ mixing. (Of course, if experimental results on $\rho^0 \to \pi^0\gamma$, $K_0^{*} \to K_0\gamma$ persist).

Note that our consideration is not affected by taking into account the mixing with new vector meson $\psi(3100)$ (in the framework of SU(4) symmetry). Indeed, the ω-φ mixing angle practically is not altered /9/ and, besides, the contribution of constant $g_{\psi\pi^0}$ to sum rules (4),(11) is negligible $(|g_{\psi\pi^0}| \ll |g_{\rho\pi^0}|, |g_{\omega\pi}|)$.

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x) At present, it is difficult to say which ω-φ mixing scheme is better for these processes because experimental information on them is rather poor.

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