Radiative decay of mesons in broken SU(3)

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In this note we show how it is possible to fit the relative radiative decay rates of vector mesons using the vector-dominance model with only one SU(3)-breaking parameter.

Recently, a number of papers[1] have been published on the subject of the radiative decays of vector mesons and the deviation of these relative decay rates from SU(3)-symmetric predictions. Some of these papers have used several SU(3)-breaking parameters in order to fit the data. In this note we shall indicate how it is possible to fit the data using the vector-meson-dominance model of Gell-Mann, Sharp, and Wagner[2] with only one SU(3)-breaking parameter.

SU(3)-symmetry breaking is introduced in two ways.

(1) Photon–vector-meson junction. The relative strength of the V-γ junctions has been investigated before by one of us[3] under the assumption of asymptotic nonet symmetry. It was found that

$$\frac{m_\rho^2}{f_\rho^2} : \frac{m_\omega^2}{f_\omega^2} : \frac{m_\phi^2}{f_\phi^2} = 3 : \sin^2\theta_V : \cos^2\theta_V , \qquad (1)$$

where θ_V is the ω-ϕ mixing angle. According to the quadratic mass formula, $\theta_V = 39°$. We may reinterpret Eq. (1) in terms of the quark model as

$$\frac{m_u}{m_s} \simeq \frac{m_\omega}{m_\phi} = 0.77 , \qquad (2)$$

in agreement with independent estimates (Barnes, Isgur[1]).

TABLE I. A comparison of theoretical predictions and experimental results for various radiative meson decays. The parentheses indicate input.

Decay	Theoretical width (keV)	Experimental width (keV)	Ref.
$\omega \to \pi\gamma$	(880)	880 ± 80	5
$\rho \to \pi\gamma$	103	35 ± 10	6
$\phi \to \pi\gamma$	5.7	5.7 ± 2	5
$\omega \to \eta\gamma$	3.8	3.0 ± 2.5	7
$\rho \to \eta\gamma$	40	50 ± 13	7
$\phi \to \eta\gamma$	52	55 ± 12	7
$\eta' \to \omega\gamma$	17	9 ± 4	8, 9
$\eta' \to \pi\pi\gamma$	118	89 ± 27	8
$\frac{\eta' \to \rho\gamma}{\eta' \to \omega\gamma}$	8.8	9.9 ± 2	9
$\phi \to \eta'\gamma$	0.09		
$K^{*0} \to K^0\gamma$	102	74 ± 35	10
$K^{*+} \to K^+\gamma$	81	< 80	5
$\pi \to \gamma\gamma$	(7.95 eV)	7.95 ± 0.55 eV	5
$\eta \to \gamma\gamma$	0.36	0.32 ± 0.05	5
$\eta' \to \gamma\gamma$	5.9	5.9 ± 1.6	8
$\eta \to \pi\pi\gamma$	0.057	0.042 ± 0.006	5

(2) Vector-meson–vector-meson–pseudoscalar-meson vertex. The relative strengths of the V-V-P vertices has been studied before under the

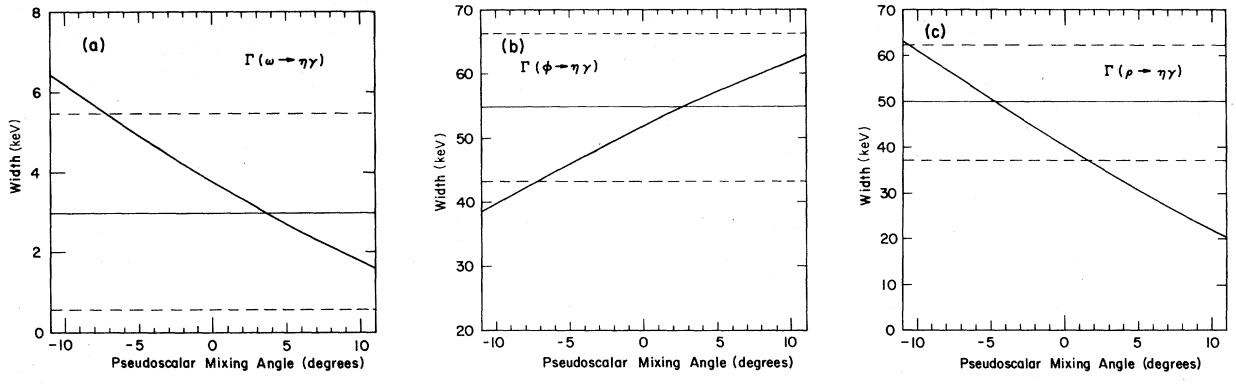

FIG. 1. Plot of decay rates as a function of the pseudoscalar mixing angle for various vector mesons. The horizontal lines represent the corresponding current experimental decay rates shown with bosons.

assumption of asymptotic nonet symmetry.[4] It was found that the relative strengths of the coupling constants $g_{V_1V_2}$ were given by

$$\frac{g_{V_1V_2P}}{m^2} = \frac{f_{V_1V_2P}}{m_{V_1}m_{V_2}}, \tag{3}$$

where $f_{V_1V_2P}$ is the SU(3)-symmetric coupling constant and m_{V_1}, m_{V_2} are the masses of the two vector mesons associated with that vertex.

Using the above prescription for SU(3)-symmetry breaking, we plot some of the decay widths as a function of θ_P in Fig. 1. It can be seen that they are all consistent with $\theta_P = 0$ or θ_P equal to a small mixing angle. Therefore, in Table I we list the various radiative decay widths calculated for a pseudoscalar mixing angle of zero and compare the results with experiment. The agreement is quite good except for $\rho \to \pi\gamma$. In particular, we are able to give a satisfactory account of the recently measured width $\Gamma(\eta' \to \gamma\gamma)$.

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