Rare Decay Modes of K^*†

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Assuming ρ-meson dominance, the branching ratio $\Gamma(K^*\to K\pi\pi)/\Gamma(K^*\to K\gamma)$ has been calculated to be 1/63. Estimating the $K^*K\rho$ coupling from unitary symmetry and the decay of the π^0 gives $\Gamma(K^*\to K\gamma)/\Gamma(K^*\to K\pi)\cong 0.15\%$, a factor of 5 lower than previous estimates.

ASSUMING ρ-meson dominance in the sense of dispersion theory, the branching ratio $\Gamma(K^*\to K\pi\pi)/\Gamma(K^*\to K\gamma)$ can be estimated independent of arbitrary coupling constants. The ρ is treated as almost stable; i.e., the propagator is taken to be that of a stable particle. The calculation is similar to that of Gell-Mann, Sharp, and Wagner[1] for the ω decay.

We take the following interactions:

$(f_{K^*K\rho}/M)\epsilon_{\mu\nu\lambda\sigma}k_\mu\epsilon_\nu q_\lambda\eta_\sigma$ at the $K^*K\rho^0$ vertex,

$f_{\rho\pi\pi}\eta_\mu(p_1-p_2)_\mu$ at the $\rho\pi\pi$ vertex,

$\gamma_{\gamma\rho}$ at the $\rho\gamma$ vertex.

(See Figs. 1 and 2 for notation.)

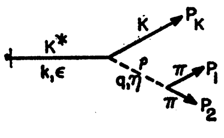

FIG. 1. Lowest order diagram for $K^*\to K\pi\pi$, showing notation.

Then

$$\Gamma(K^*\to K\gamma)=\frac{1}{24}\frac{f^2{}_{K^*K\rho}}{4\pi M^2}\frac{\gamma^2{}_{\gamma\rho}}{m_\rho{}^4}\frac{(m^2{}_{K^*}-m^2{}_K)^3}{m^3{}_{K^*}},$$

$$\Gamma(K^*\to K\pi\pi)=\frac{1}{\pi}m_{K^*}\frac{f^2{}_{K^*K\rho}}{4\pi M^2}\frac{f^2{}_{\rho\pi\pi}}{4\pi}\times\int\frac{|\mathbf{p}_1\times\mathbf{p}_K|^2dE_1dE_K}{[m_\rho{}^2-m_{K^*}{}^2+2m_{K^*}E_K-m^2{}_K]^2},$$

where the statistical factors due to isospin conservation have already been inserted [i.e., $\Gamma(K^*\to K\pi\pi)$ includes all charge configurations in the final state]. Since there is only about 100-MeV kinetic energy released in the $K\pi\pi$ decay mode, the three-body phase space can be treated nonrelativistically. The result is

$$\Gamma(K^*\to K\pi\pi)=\frac{1}{4}\frac{1}{\mu+1}\left[\frac{\mu-1}{\mu+1}\right]^{3/2}m_{K^*}m_\pi{}^2\times\frac{f^2{}_{K^*K\rho}}{4\pi M^2}\frac{f^2{}_{\rho\pi\pi}}{4\pi}\frac{Q^4}{[m_\rho{}^2-(m_{K^*}-m_K)^2]^2},$$

where

$$Q=m_{K^*}-m_K-2m_\pi,$$
$$\mu=1+m_K/m_\pi,$$

and we have put $E_K=m_K$ in the ρ propagator. [An expansion of the propagator to first order in $(E_K-m_K)/m_K$ changes the result by about 10%.]

Now if the ρ meson also dominates the nucleon isovector form factor, we have $\gamma_{\gamma\rho}=em_\rho{}^2/f_{\rho\pi\pi}$.[2] Also, $f_{\rho\pi\pi}$ is determined from the observed ρ decay width to be $f^2{}_{\rho\pi\pi}/4\pi\cong 2$. Thus, we obtain

$$\Gamma(K^*\to K\pi\pi)\cong 1.9\times 10^{-4}\frac{f^2{}_{K^*K\rho}}{4\pi M^2}m_\pi{}^3,$$

$$\Gamma(K^*\to K\gamma)\cong 1.2\times 10^{-2}\frac{f^2{}_{K^*K\rho}}{4\pi M^2}m_\pi{}^3,$$

$$\frac{\Gamma(K^*\to K\pi\pi)}{\Gamma(K^*\to K\gamma)}\cong\frac{1}{63}.$$

Using the result of unitary symmetry $f^2{}_{K^*K\rho}/4\pi M^2=\frac{3}{4}f^2{}_{\omega\rho\pi}/4\pi M^2$ and estimating $f^2{}_{\omega\rho\pi}/4\pi M^2=0.02/m_\pi{}^2$ from the decay of the π^0,[1] we find

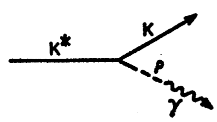

FIG. 2. Lowest order diagram for $K^*\to K\gamma$.

$$\Gamma(K^*\to K\gamma)\cong 2.5\times 10^{-2}\text{ MeV},$$
$$\Gamma(K^*\to K\gamma)/\Gamma(K^*\to K\pi)\cong 0.15\%,$$

which is lower than previous estimates by about a factor of 5.[3,4]

Fujii,[4] using the Fermi statistical model, finds $\Gamma(K^*\to K\pi\pi)/\Gamma(K^*\to K\gamma)\cong 5$. However, in this result, the angular momentum barrier due to the K^* spin was not taken into account.

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[2] J. J. Sakurai, in *Proceedings of the "Enrico Fermi" International School of Physics* (Villa Monastero, Varenna, Como, Italy). See also, M. Gell-Mann and F. Zachariasen, Phys. Rev. **124**, 953 (1961); Y. Nambu and J. J. Sakurai, Phys. Rev. Letters **8**, 79 (1962).

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