# Rare Decay Modes of $K^*$†

MITCHEL J. SWEIG*
*The Enrico Fermi Institute for Nuclear Studies and the Department of Physics, The University of Chicago, Chicago, Illinois*

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Assuming $\rho$-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 $\pi^0$ gives $\Gamma(K^*\to K\gamma)/\Gamma(K^*\to K\pi)\cong 0.15\%$, a factor of 5 lower than previous estimates.

ASSUMING $\rho$-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 $\rho$ 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 $\omega$ 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.)

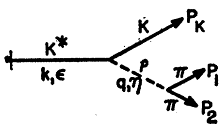


FIG. 1. Lowest order diagram for $K^*\to K\pi\pi$, showing notation.

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 $\rho$ 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 $\rho$ 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 $\rho$ 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 $f^2_{\omega\rho\pi}/4\pi M^2=0.02/m_\pi^2$

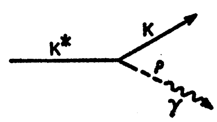


FIG. 2. Lowest order diagram for $K^*\to K\gamma$.

from the decay of the $\pi^0$,[1] we find

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

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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