MEASUREMENT OF DIRECT EMISSION $K^+ \to \pi^+ \pi^0 \gamma$ DECAY

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The direct emission (DE) component of the $K^+ \to \pi^+ \pi^0 \gamma$ decay consists of magnetic and electric transitions. At $O(p^4)$ in ChPT, the magnetic amplitude consists of a reducible amplitude [1] which is unambiguously determined by the WZW functional [2] with a chiral anomaly and of a direct anomalous amplitude[3], arising from odd-parity octet operators. There is no definite prediction from ChPT of the electric transition amplitude, which depends on undetermined constants. Since the electric amplitude interferes (INT) with the dominant inner bremsstrahlung (IB) amplitude, it may be distinguished from the magnetic amplitude, which does not.

The differential decay width for the decay $K^+(p) \to \pi^+(p_+)\pi^0(p_0)\gamma(q)$ is expressed in terms of a Lorentz invariant variable $W^2 \equiv (p{\cdot}q)(p_+{\cdot}q)/(m_{\pi^+}^2 m_K^2)$. The differential width can be written in terms of the IB differential width as

$$\frac{\partial^2\Gamma}{\partial T_+ \partial W} = \frac{\partial^2\Gamma_{IB}}{\partial T_+ \partial W}\left[1 + 2\frac{m_{\pi^+}^2}{m_K} Re\left(\frac{E}{eA}\right) W^2 + \frac{m_{\pi^+}^2}{m_K^2}\left(\left|\frac{E}{eA}\right|^2 + \left|\frac{M}{eA}\right|^2\right) W^4\right] \quad (1)$$

where T_+ is the kinetic energy of the charged pion, A is the decay amplitude for $K^+ \to \pi^+\pi^0$, and E and M are electric and magnetic DE amplitudes, respectively. The direct emission amplitudes E and M are independent of W, while the IB decay amplitude is proportional to $1/W^2$, and thus dominates in the small W region.

The E787 detector[5] at the Alternating Gradient Synchrotron of Brookhaven National Laboratory was used to study $K_{\pi 2\gamma}$. Kaons of 790 MeV/c were incident on a solenoidal spectrometer with a 1.0 Tesla field. Measurements of momentum, kinetic energy and range of charged decay products were performed. A hermetic calorimeter system consisting of barrel and endcap detectors measured the positions and energies of photons and other particles from K^+ decays. A total of 19836 events survived all off-line selection cuts, eight times more than the previous experiments [4].

Figure 1a shows the W projection of the signal events in the T_+ signal region 55 MeV $< T_+ <$ 90 MeV. The dashed curve is a best fit to IB alone with a χ^2 of 61 for 7 degrees of freedom. The solid curve is the best fit to the sum of IB and DE and gives a χ^2 of 7.9 for 6 degrees of freedom.

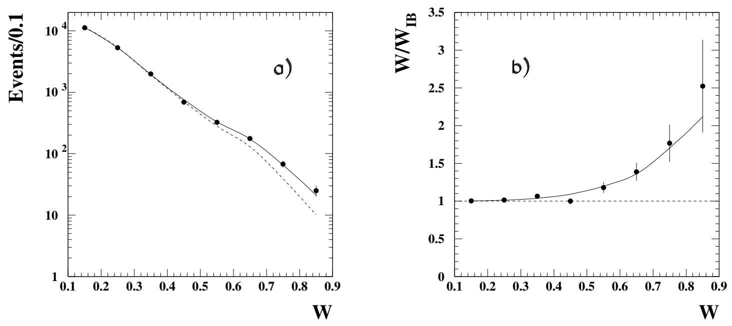

Figure 1: a) W spectrum of the observed events and best fits to IB+DE (solid curve) and IB alone (dashed curve); b) Measured W spectrum normalized to the IB spectrum.

Normalized to the IB spectrum the deviation of the measured spectrum at large W is shown in Figure 1b. The branching ratio for DE is determined to be $B^{T_+}(DE) = (4.7 \pm 0.8) \times 10^{-6}$ in the signal T_+ region. The best fit to the sum of IB, DE and INT gives the INT component to be $(-0.4 \pm 1.6)\%$ of the IB component with a χ^2 of 7.8 for 5 degrees of freedom. We conclude that no interference term is required for the fit to this spectrum. Assuming a pure magnetic transition for the DE amplitude, the result for $B^{T_+}(DE)$ gives $|M| = (2.1 \pm 0.2) \times 10^{-7}$ for the dimensionless magnetic amplitude in Eq. (1). The reducible anomalous amplitude $|-eG_8 m_K^3/2\pi^2 f|$ in Ref. [1] is $|M| = 1.8 \times 10^{-7}$ with standard $O(p^2)$ ChPT coupling constants, $f = 93$ MeV and $|G_8| = 9 \times 10^{-6}$ GeV^{-2}. This result supports the hypothesis that the dominant contribution to DE is due to the reducible anomalous amplitude and the other magnetic contributions are small or cancel.

References

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