A Model for $K_{e5}$ Decay.

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(ricevuto il 16 Gennaio 1967)

Summary. — The rate for $K_{e5}$ decay is computed using a pion-pole model. A large enhancement is found over previous estimates based on direct-interaction and $\gamma$-pole models.

1. — Introduction.

The purpose of this paper is to present a new estimate of the rate for the rare $K$-meson decay mode

\[ K^\pm \rightarrow e^\pm + \nu + \pi^+ + \pi^- + \pi^0, \]

which has not yet been observed. This decay has been discussed previously using a direct-interaction model \(^{(1)}\) and an $\gamma$-pole model \(^{(2)}\). The rates obtained were very small, consistent with the nonobservance of the decay mode.

The small rate for $K_{e5}$ decay is primarily due to the limitations of the five-body phase space since there are no dynamic restrictions on the decay. In fact, in contrast to the $K_{s1}$ decay, the decay rate may be unexpectedly large as the result of dynamic enhancement. This could occur if the three-pion state were strongly influenced by final-state interactions.

If a meson with the correct quantum numbers (angular momentum, isospin, etc.) existed in the mass range $3m_\pi < m < M_K$, and were strongly coupled to the three-pion system, this meson-pole channel would dominate the decay and give rise to a large enhancement of the rate.

Since such a meson does not exist, we must look at the observed mesons with masses close to this range which may still provide the dominant channel for the decay, despite the fact that they are off the mass shell.

The $\eta$-pole model discussed previously (1, 2) does not yield a very large rate due to the fact that the $\eta$ is not sufficiently strongly coupled to the three-pion system.

Alternatively, the pion-pion interaction is expected to be strong. Thus, a pion-pole model together with a four-pion coupling may give rise to a large enhancement which could give a predicted rate large enough to justify an experimental search for the $K_{s3}$ decay mode.

Brown and Singer (3) have suggested a model for $\eta$ and K decays which employs a $J = 0$, $I = 0$ $\sigma$-meson channel for the neutral two-pion system. The $\sigma$-meson not only provides a convenient description of the low-energy pion kinematics, but we may also use the $\sigma\pi\pi$ coupling constant to determine the effective $\pi \to 3\pi$ strength.

Our results should not be sensitive to the parameters ($m_\sigma$ = mass, $\Gamma_\sigma$ = width) of the $\sigma$-meson since it is well known that a linear approximation to the $\sigma$ propagator gives an adequate fit to the experimental data in $\tau$ decays (4) and radiative $\tau$ decays (5).

2. – Calculation of the decay rate.

The matrix element for $K_{s3}$ decay is obtained from Fig. 1:

\[
\mathcal{M} = \left( \frac{1}{2\pi} \right)^5 g_1 g_2^2 \bar{u}_s(p_s) \gamma^\lambda (1 + \gamma_5) u_s(p_s)(Q + P)_\lambda \cdot \frac{1}{(P^2 - m_\sigma^2)} \frac{1}{(q^2 - m_\pi^2)} \delta^4(Q - P - q - q - q),
\]

![Fig. 1. - Diagram for $K_{s3}$ decay.](image)