Application of the On-Mass-Shell Current Algebra to the $K_t$ Form Factor.

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Summary. — We wish to evaluate the $K_t$ decay amplitudes with a current algebra formalism while keeping the pions on the mass shell. This calculation is done using a technique described previously, in which the axial vector currents are modified and the equal-time commutation relations of the new currents verified. As a result of using these new currents, and for not needing to extrapolate the pion mass, the reduction formula contains some terms which must be evaluated by summing over sets of the intermediate states. In this application we note that dominating intermediate states are the $\pi$, $K^*$, $A_1$, $\pi$ mesons, and the two-particle systems ($K^*K$) and ($\pi K$). Using the known data for the $\pi$, $K$, $K^*$ and $A_1$ mesons we find a surprising sensitivity of the ratio of the decay form factors, i.e. $\xi(0) = f_-(0)/f_+(0)$, to the change of the $\pi$ mass, width and decay constant. Within the expected ranges of these parameters, values of $\xi(0)$ ranging from $-0.1$ to $-0.85$ can be obtained by the present treatment.

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1. - Introduction.

The evaluation of the form factor for the $K_L$ decay has been an interesting problem for the last several years. Various investigators have found conflicting values for the ratio $\xi(t = 0)$ of these two form factors (where $t$ is the $K^{-}\pi$ momentum transfer). In general, experiments that measure the leptons' polarization have led to a rather large $|\xi|$ (as much as $1.45 \pm 0.07$) \(^{(1)}\), while experiments that analyze Dalitz plots have produced a smaller $\xi$, averaging $-0.15 \pm 0.5$ \(^{(1,2)}\). The theoretical analyses of this decay are generally based on the usual off-mass-shell treatment, carried out in several ways. The early approaches which are based on either PCAC (partially conserved axial vector current) and soft pions (i.e., $m_\pi \to 0$ extrapolations) \(^{(3)}\), or else on dispersion relations \(^{(4)}\), lead to relatively small $|\xi|$ values, $< 0.5$. As an improvement, the hard-meson technique is used by several authors \(^{(5)}\). This method consists essentially of a tree graph approximation for which the coupling constants of the particles involved in the decay are evaluated from an effective Lagrangian, making use of i) PCAC current algebra; ii) the smoothness of the vertex functions for small momentum transfer and for $0 < p^2 < m^2$, where $p$ is the 4-momentum of the particle with a mass $m$; iii) the single-particle saturation of the current's matrix elements and iv) use of the PCAC-type relations for the currents associated with heavy mesons such as $K$, $\pi$, $K^*$, etc. The possibility of the unsoundness of one or more of these assumptions has been already pointed out in the literature \(^{(6)}\). In another approach, the off-mass-shell decay amplitude is corrected, for small momentum transfers, assuming the $\pi$-meson intermediate state to be dominant while the well-known contribution of the $K^*$ is ignored \(^{(7)}\). In this way, for a $\pi$ mass $m_\pi = 1$ GeV to $\infty$, the $|\xi|$ value is found to be 0.1 to 0.27. There are other techniques, for instance, using dispersion

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\(^{(1)}\) See the review on the $K_L$ decay by M. K. Gaillard and L. M. Chounet: CERN Report No. 70-14 (1971).

\(^{(2)}\) For recent data, see the report by S. Wojcicki: *Proceedings of the XVI International Congress on High-Energy Physics, Batavia, 1972* (to be published).


\(^{(5)}\) The "hard meson" technique has been used by many authors; see R. Arnowitt: Rapporteur talk, *Proceedings of the Conference on $\pi\pi$ and $K\pi$ Interactions* (Argonne, Ill., 1969).

\(^{(6)}\) R. Arnowitt, M. H. Friedman and P. Nath: *Nucl. Phys.*, 10 B, 578 (1969). The results in this reference are comparable to those obtained by the tree graph method in the present work.