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G. K. O'Neill (Palmer Physical Laboratory, Princeton University) :

THE STUDY OF K^o MESON DECAYS BY COLLIDING BEAMS.

Electron-positron storage rings have been built at Frascati, Orsay and Novosibirsk for the study of problems in the strong and electromagnetic interactions : electromagnetic coupling constants to vector mesons, the timelike photon propagator, form-factors of strongly-interacting particles and the properties of strongly-decaying resonances.

The purpose of this note is to point out that these storage rings can also be applied to at least one significant problem in weak interaction physics : the branching-ratios and lifetime of the long-lived neutral K-meson, K_L^o. Further, given sufficiently high performance of the Frascati storage ring, it seems not out of the question that unusually clean experiments on the CP-violation parameters η_{+-} and η_{oo} could be performed by colliding beams.

The special property of e^+e^- storage rings which should make this possible is that they can produce the ϕ resonance in a precisely known way, at rest, and free of all other particles. The ϕ, in turn, has the special properties that its production cross-section is very high, its branching ratio to neutral K-meson pairs is also high ($31 \pm 2\%$), and it is so near the $2K^o$ threshold that K_L^o mesons from the decay of ϕ's at rest are slow, and therefore have a high probability of decay in an experimental apparatus even of modest size. The ϕ has I-spin zero, spin 1, odd parity and is odd under C. Its neutral kaon decay is therefore into the $K_S^o K_L^o$ combination either K^o then serving as a signature for the production of the other.

The production graph for the ϕ is given in fig. 1, and its principle radiative correction[(1)] graph in fig. 2.

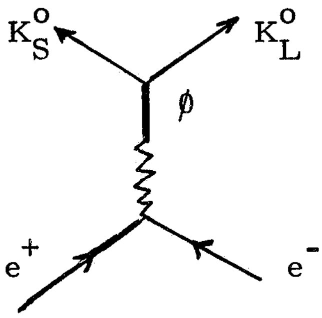

FIG. 1

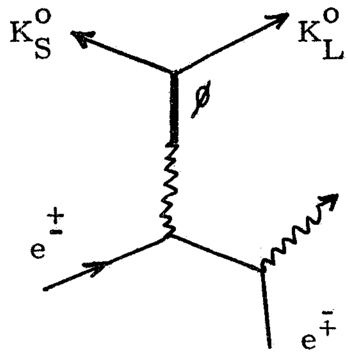

FIG. 2

Note that the dominant real-photon emission is in the initial state, from an $e^\pm$ line; however, if such emission is of more than about one MeV the energy is shifted well off the very narrow ϕ resonance; this suppresses radiative processes relative to the non-radiative principal diagram, and has the effect of insuring that the K_L^o and K_S^o are nearly always colinear and of equal, known momenta.

Considering realistic detection apparatus, it is assumed that the useful decay length for K_L^o is 50 cm, that only those K_L^o which accompany K_S^o decaying by the $\pi^+\pi^-$ mode are usable, and that there is a 50% chance of measuring all four charged tracks from a 4-prong event within the fiducial volume. The expected rate is then the product of the following numbers :

- Luminosity of Adone storage ring (nominal): $0.7(10)^{33}/cm^2$-hour
- Measured peak[(x)] cross-section for ϕ : 3.9×10^{-30} cm^2
- Branching ratio[(x)] of ϕ to $K_S^o K_L^o$: $0.312 \pm .016$
- Probability of decay of a 107 MeV/c K_L^o in 50 cm : 0.14
- Branching ratio of K_S^o into $\pi^+\pi^-$: 2/3
- Probability of measuring all 4 charged products: 0.50
- B. R. $\equiv$ branching ratio of K_L^o into the mode of interest.

This product is 40(B. R.) per hour. In 400 hours of data-taking the expected numbers of particular K_L^o decays, each one tagged by a

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(x) - Measured by the ACO group, as reported by Perez-y-Jorba at the 1968 Vienna Conference on High-Energy Physics. An earlier calculation by Gatto gave 8.5×10^{-30} cm^2 for the peak cross-section; the Sept. '67 LRL table quotes $0.40 \pm .03$ for the branching ratio for $\varphi \longrightarrow K_S K_L$.

$K_S^o \rightarrow \pi^+\pi^-$, are:

$\pi^{\pm} e^{\mp} \nu$: 5,700 ; $\pi^{\pm} \mu^{\mp} \nu$: 4,400 ;

$\pi^+\pi^-\pi^o$: 1900 ; ($\pi^o\pi^o\pi^o$: 3600) ;

$\pi^+ \pi^-$: 25 (CP violating; measures η_{+-})

$\pi^o \pi^o$: 12 (CP violating; measures η_{oo}, here assued $\eta_{oo} = \eta_{+-}$).

The simpl e experimental conditions and the freedom from background which characterize events made by e^+e^- annihilation with a four-prong signature suggest that this sort of experiment can considerably improve knowledge of the K_L^o lifetime and branching ratios, and given above-minimum performance of Adone, may also serve as a useful check on the controversial η_{oo} parameter.

Studies of K_L^o leptonic-decay charge asymmetries and of the $\Delta S/\Delta Q$ rule are not accessible to the present generation of storage rings; they require a luminosity which can only be reached by the use of a new technique (low-beta sections) which has not yet been applied in practice.

REFERENCE -

(1) - G. Pancheri, LNF-68/26 (1968) and earlier references listed therein.