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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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Memorandum

To : EEC

From : A. Böhm, P. Darriulat, C. Grosso, V. Kaftanov, K. Kleinknecht, H.L. Lynch, H. Ticho and K. Tittel. C. Rubbia

Subject : Phase ambiguities of CP violating amplitude in K^0 decay.

The recent important results of J.M. Gaillard et al.[1] and J. Cronin et al.[2] have shown that the modulus of

$$\eta_{00} = \frac{\text{Amplitude } (K_0^L \to 2\pi^0)}{\text{Amplitude } (K_0^S \to 2\pi^0)}$$

is about twice η_{+-}, the corresponding quantity for the $\pi^+\pi^-$ decay channel. The determination of $|\eta_{+-}|$ and $|\eta_{00}|$ is not sufficient to carry out a complete phenomenological analysis of the process as first discussed by Wu and Yang[3]. One further experimental quantity like arg (η_{+-}) or arg (η_{00}) is needed. We are at present engaged in a measurement of arg (η_{+-}). A further ambiguity between two solutions is to be expected because the solution of a quadratic equation is required.

Taking the only estimate[4] of arg (η_{+-}) obtainable so far, arg $(\eta_{+-}) = (0.6 \pm 0.23)$ sign (Δm) and assuming CPT, the authors of Ref. 1) have indicated two following alternative solutions:

1) $\epsilon = 5.7 \times 10^{-3}$ $\epsilon' = 1.9 \times 10^{-3}$

2) $\epsilon = 0.1 \times 10^{-3}$ $\epsilon' = 3.9 \times 10^{-3}$,

where ϵ, ϵ' have the definition of Ref. 3), that is $2\eta_{+-} = \epsilon + \epsilon'$, $2\eta_{00} = \epsilon - 2\epsilon'$. Solution (2) is remarkable in the sense that the contribution to CP violation due to the mass matrix (ϵ) is much smaller than the one from the $K \to 2\pi$ decay amplitude.

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A possible way of resolving such an ambiguity is a measurement of arg (η_{00}), as proposed by J.-. Gaillard, M.R. Jane and T.J. Ratcliffe[5]).

We would like to point out that there exists another, independent experimental approach which could be presumably carried out with our present detecting apparatus in the neutral beam b_{13} built for the experiment S49. The two alternative solutions predicting charge values for the asymmetry in the leptonic decays from a long-lived K_o state are different enough to be detectable by our present equipment.

Assuming $\Delta Q = \Delta S$ and CPT, one can show that

$$a = \frac{\text{Rate } (K_o^L \rightarrow \pi^- \ell^+ \nu)}{\text{Rate } (K_o^L \rightarrow \pi^+ \ell^- \nu)} = 1 + 4 \text{ Re } (\epsilon) + \text{terms of order } |\epsilon|^2$$

and that

$$\arg \epsilon \simeq \arctan \frac{2 \Delta m}{\Gamma_S - \Gamma_L} .$$

Solutions (1) and (2) give the expectations:

Solution (1) $a = +0.016$
Solution (2) $a = +0.003$.

The experimental uncertainties in the $\Delta Q = \Delta S$ rule are sufficiently small not to affect the conclusion.

We would like to collect about 2×10^5 decays of the type $K_L^o \rightarrow \pi^{\pm} e^{\mp} \nu$, and for that we need to take in the order of 400,000 pictures. More than one picture could be taken at each CPS burst. We estimate that four parasitic weeks with 5×10^{10} protons/pulse incident on b_{13} target over 200 msec spill-out time are adequate. The average speed of analysis of this type of pictures by Luciole is at present of about 2000/hour. Therefore, 200 hours of Luciole time are required to carry out the complete measurement of all pictures. No programme development is necessary because the picture format will be the same as the one of the S49 experiment.

We are considering at present possible systematic errors and instrumental asymmetries which are evidently required to be much less than the small, 1.5%, difference in the expected value of a for the two solutions.

We have not been able, so far, to find any such spurious effect which could be of the size of the searched for effect. A complete discussion about this point will be contained in a further, more complete, experimental proposal.

The measurement could be carried out after the main S49 run (weeks 3, 4, 5 and 6).

The earliest time which we could start the data taking is during neutrino weeks 11 and 12, provided the PS is operated with some (200 msec) flat top, and one or two bunches are left in the accelerator and slow-extracted through e_3.

REFERENCES

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2) J.M. Cronin, P.F. Kunz, W.S. Risk, P.C. Wheeler (to be published in Phys.Rev.Letters).

3) T.T. Wu, C.N. Yang, Phys.Rev.Letters 13, 380 (1964);
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4) C. Rubbia, J. Steinberger, Physics Letters 23, 167 (1966).

5) Paper submitted to EEC and NPRC 66/1554/5 and private communications.