ON THE POSSIBILITY OF THE VIOLATION OF CP INVARIANCE AND NEUTRAL LEPTON CURRENTS IN WEAK INTERACTIONS

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LEE and Yang [1] indicate that in the "schizon" model there is a possibility for the violation of T or CP invariance of weak interactions associated with a Lagrangian of the form $j_1 \times j_2$, where j_1 is a combined even isoscalar neutral hadron current which does not change strangeness, and j_2 is a combined odd neutral hadron current which changes strangeness. An even more obvious possibility of this sort may be found in the model of weak interactions with broken isotopic symmetry [2], appearing in the usual schizon model of Lee and Yang.

With the goal of excluding transitions with $\Delta S = 2$, an isoscalar vector boson $X_\alpha^{u(0)}$ was introduced in [2], and under the strict demands of CP invariance proved "sterile" in the approximation of neglecting non-diagonal mass terms. But the recently appearing indication of the violation of CP invariance of weak interactions [3] might, if confirmed, make attractive other possibilities which lead to a "localized" violation of CP invariance of weak interactions, in which the above term of the interaction $j_1 \times j_2$ is a "schizon" with the CP-properties of a $X_\alpha^{u(0)}$ boson. Insofar as the boson $X_\alpha^{u(0)}$, as mentioned in [2], is a singlet (in the sense of higher, possibly unitary symmetries in the approximation of neglecting non-diagonal mass terms), there is a natural possibility for the violation of the universality of the coupling constants for weak interactions, arising through an exchanged $X_\alpha^{u(0)}$ boson, and corresponding to the observed small violation of CP invariance.[3]

The present work has the goal of pointing out an interesting possibility related to the question under consideration. Taking the above-mentioned local character of the violation of CP invariance, one may consider that a symmetric neutral lepton current is completely absent in CP invariant weak interactions, but enters in combination with an even-parity neutral current j_1, and thus may participate in weak interactions in the violation of CP invariance. In such a case one might expect the appearance of neutral lepton currents in CP-noninvariant processes with a change in strangeness; for example

$$K^+ \to \pi^+ + e^+ + e^-, \quad K^+ \to \pi^+ + \mu^+ + \mu^-,$$
$$K^+ \to \pi^+ + \nu + \bar{\nu}. \qquad (1)$$

In [3] it was found that the fraction of the number of processes violating CP-invariance in the decay of K_2^0 mesons is $\Gamma_2(\pi^+\pi^-)/\Gamma_2 \cong 2 \times 10^{-3}$. It follows from this that processes violating CP invariance are approximately $\sim 4 \times 10^{-6}$ less probable than those conserving it. Thus for the relative probability of the decays (1) we find

$$\Gamma_+(\pi^+ l\bar{l}) / \Gamma_+ \cong 1 \cdot 10^{-7}, \qquad (2)$$

where $l = e$ or ν. For $l = \mu$ this estimate is still several times smaller. Scanning of the decays $K^+ \to \pi^+ + e^+ + e^-$ was carried out by the Berkley-Wisconsin group [4], who found an upper limit

$$\Gamma_+(\pi^+ e^+ e^-) / \Gamma_+ \leqslant 1.1 \cdot 10^{-6}.$$

In comparing (2) with experiments it is necessary to keep the following in mind. In the work of Okun and Rudik [5] and following articles [6-8] the possibility of the decay $K^+ \to \pi^+ + l^+ + l^-$ through the combination of weak and electromagnetic interactions was investigated, and their estimate was $\sim 10^{-6} - 10^{-7}$. Therefore the observation of such decays would not appear to be a unique indication in favor of the model being considered. There is, however, a natural distinction between mechanisms with primary neutral lepton currents and with induced currents: in the second case both the lepton current and the spatial parity are conserved, but in the first case neither are conserved [5]. Concerning the possibility of experimentally distinguishing these possibilities, they are distinguishable by mass spectra or by polarizations, although for electron decays only the latter type of experiment is suitable.

It should be especially remarked that if the mass of the intermediate boson is not very large compared to the nucleon mass, there is a unique possibility[1)] in the models under consideration (in distinction to the case of an induced lepton cloud) for the resonance production of single strange particles ($K^- + \pi^+$ and others) in future electron-positron colliding beam experiments.

The electromagnetic contribution to the decay $K^+ \to \pi^+ + \nu + \bar{\nu}$ is zero, and its observation would be a unique indication of primary neutral lepton currents.

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[1)]Practically the only decays of the neutral intermediate boson of the type in the model[2] are decays into hadron systems of the type $K^-\pi^+$ and others with $\Delta S = \pm 1$. As a crude estimate, for m_W = 2-3 GeV and $\Delta E \approx$ 1-10 MeV the mean resonance cross section is $\bar{\sigma}_R \sim 10^{-34} - 10^{-35}$ cm². Decays into symmetric lepton or hadron pairs are suppressed by a factor of $\sim 4 \times 10^{-6}$.

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NEGATIVE DISPERSION IN THE R_1 LINE OF RUBY

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It follows from the theory of dispersion that if the population of the upper level n_2 is greater than the population of the lower level n_1, the anomalous dispersion curve corresponding to a transition between these two levels should change sign. In this case the dispersion curve exhibits unusual behavior, corresponding to negative dispersion.

In a number of well known papers, Ladenburg[1] used the Rozhdestvenskiĭ hook method to study the effect of increasing the population of the upper level on the dispersion curve for lines in neon. However in his experiments the lower level population always remained larger than the upper level population.

We have studied the dispersion of light in ruby in the presence of population inversion[1)]. Under these conditions the investigated material has a very high luminescence brightness. The radiation source used to measure the index of refraction of the luminescent ruby must be still brighter. In other words, when using the photographic method the temperature of the test source must be considerably greater than the emission temperature of the luminescing ruby, which is approximately 20,000°K. A laser is the natural source to use to satisfy this condition, and for this reason a ruby laser was used as the source of test radiation.

The optical dispersion was measured with the polarizing interferometer first used in [6] and described in a paper by one of the authors [2], with a modification suggested by I. V. Obreimov: instead of using quartz to compensate for the anomalous dispersion we used a ruby crystal which was identical with the one being investigated but with its optic axis perpendicular to that of the sample.

The experimental set-up was the following (Fig. 1). Polarized light from the ruby laser RL was passed through the ruby sample P_1 whose optic axis was vertical, made an angle of 45° with the plane of the polarized light and made an angle of 90° with the direction of propagation of the test light. The beam then passed through the compensating ruby P_2 whose optic axis was perpendicular to the direction of the optic axis of ruby P_1; the light then went through a cemented quartz double wedge W, the optic axes of which were perpen-

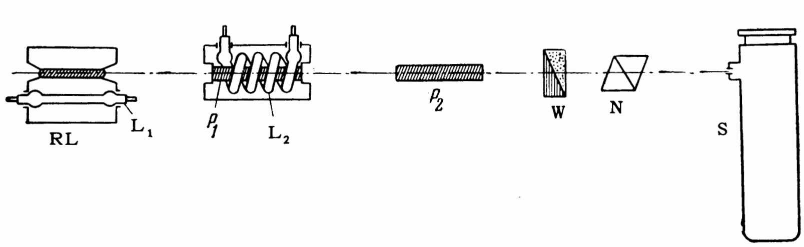

FIG. 1. Optical set-up for observation of dispersion.