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DOES THE NEUTRINO SEA LEAD TO THE ROTATION OF POLARIZATION PLANE OF LIGHT?

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DOES THE NEUTRINO SEA LEAD

TO THE ROTATION OF POLARIZATION PLANE OF LIGHT?

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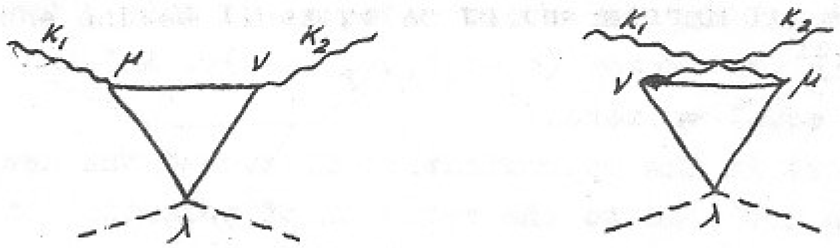
abstract

It is shown that although parity is not conserved, the neutrino sea does not lead to the rotation of polarization plane of light.

The hypothesis of the existence of the neutrino (or antineutrino)sea is very popular in modern astrophysics. Naturally, the question arises how to detect this sea. One can come across the statement[1,2] that due to parity nonconservation in weak interactions, this neutrino sea leads to the rotation of polarization plane of light. And although the optical activity predicted in the works[1,2] is very small, the observation of the effects of such an order of magnitude does not seem absolutely hopeless. In the present note I wish however to turn attention to the fact that the effect discussed does not really exist, and the statement made in the papers[1,2] is the result of evident misunderstanding.

The refraction index created by the neutrino sea, is expressed via the amplitude of photon-neutrino scattering described by the two Feynman graphs. Here the wavy lines refer to the photons, the dotted lines refer to the neutrinos, and the closed



loop drawn by the solid line corresponds to the virtual electron. Assume as usually that the weak interaction is CP even and the neutrino has two components. In virtue of Furry theorem, the vector part of the neutral electronic current cancels out, so that the interaction of electron with neutrino contributing to the process discussed is

$$\frac{G}{\sqrt{2}}\,\bar{e}\gamma_\lambda\gamma_5 e\ \bar{\nu}\gamma_\lambda(1+\gamma_5)\nu \qquad (1)$$

Simple formal calculation of the matrix element determined by the presented graphs leads at $k_1=k_2=k$ to the following expression

$$M_{\mu\nu}=\frac{G}{\sqrt{2}}\frac{4\alpha}{3\pi}\, i\varepsilon_{\lambda\mu\nu\rho}k_\rho\bar{\nu}\gamma_\lambda(1+\gamma_5)\nu \qquad (2)$$

This result can be easily shown to be in complete agreement with

with that of the work[1]. It is immediately clear however that the scattering amplitude of the photon depends on the field strength and hence in the absence of pole diagrams depends on k at least quadratically. Therefore the result (2) cannot be true. The point is that the graphs under discussion should be regularized when computed. The forward scattering amplitude found in this way turns to zero. It is evident, e.g., in the case of the Pauli-Villars regularization since the expression (2) does not depend on the mass of the virtual fermion and should therefore cancel out completely.

In fact, as it was shown by Gell-Mann[3], the photon-neutrino scattering amplitude turns to zero even at $k_1 \neq k_2$. (I am grateful to A.I.Vainshtein and S.G.Matinyan who have turned my attention to this circumstance.) Indeed, it is clear from the consideration in the annihilation channel that since two photons cannot have total angular momentum equal to unity, the amplitude should contain the factor $(k_1-k_2)_\lambda \bar{\nu}\gamma_\lambda(1+\gamma_5)\nu$. And this quantity is evidently equal to zero.

Therefore, in the approximation discussed the neutrino sea not only does not lead to the rotation of polarization plane of light, but does not influence at all light propagation.

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