IS THE RIGHT-HANDED MAJORANA NEUTRINO A TACHYON?

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ABSTRACT

It is shown that the existence of a majorana tachyon neutrino is consistent within the present status of the theory.

RESUMEN

Se demuestra que la existencia de un neutrino taquión de majorana es consistente con el estado actual de la teoría.

In a recent letter Chodos *et al.*[1] propose, the interesting idea, that one of the neutrinos (in particular the muon neutrino) could be a tachyon. They consider a Lagrangian where the kinetic energy term has been changed to $i\bar{\psi}\gamma_5 \not{\partial}\psi$. The effect of the γ_5 is to introduce a minus sign when the right-handed part of the wave function is considered. This fact will allow the right-handed neutrino to behave like a tachyon.

On the other hand, it is well know in the literature that the right-handed neutrino could be a majorana particle[2]. This will avoid the right-handed currents to participate in the weak phenomenology at low energies.

It this note we propose to consider the right-handed neutrino as a majorana tachyon. We will examine some of the implications following this assumption.

Out starting point will be the equation given in the Chodos *et al.* letter,

$$L = i\,\bar{\psi}\gamma_5 \not{\partial}\psi - m_\nu\,\bar{\psi}\,\psi \quad , \tag{1}$$

and we look for the conditions that will be consistent with the relation $\psi = \psi_c$, which is the majorana condition. We have

$$\psi = \psi_c = C\bar{\psi}^T = C\gamma_o\psi^* \quad , \tag{2}$$

therefore

$$\psi^* = C^*\gamma_o^*\psi$$

and (3)

$$\psi = C\gamma_o(C^*\gamma_o^*\psi) = C\gamma_o C^*\gamma_o^*\psi \quad ,$$

working in a representation in which γ_o is real, the Eq. (3) implies that

$$C\gamma_o C^*\gamma_o = 1 \quad . \tag{4}$$

Eq. (4) is the condition we were looking for. In order to obtain from Eq. (1) the equation for the conjugated field, ψ_c, we need to have the following relation:

$$C\gamma_5\gamma_\mu^T C^{-1} = \gamma_5\gamma_\mu \quad , \qquad (5)$$

where C is still unespecified. But if the matrix C has to obey Eq.(4) and Eq.(5) at the same time then we can conclude that the ψ given in Eq.(2) is a majorana tachyon. In the next we are going to prove this. We make use of the relation $\gamma^o\gamma^{\mu *}\gamma^o = \gamma^{\mu T}$ to get

$$C\gamma_5\gamma_o\gamma_\mu^*\gamma_o C^{-1} = \gamma_5\gamma_\mu \quad ; \qquad (6)$$

form here we obtain

$$\gamma^* = \gamma_5 C^* \gamma_5\gamma_o\gamma_\mu\gamma_o (C^{-1})^* \quad , \qquad (7)$$

where we take γ_5 to be real. Putting (7) into (6) and taking into account that $\gamma_o\gamma_5 + \gamma_5\gamma_o = 1$ and $\gamma_5^2 = 1$ we arrive to

$$C\gamma_o C^* \gamma_o\gamma_5\gamma_\mu\gamma_o C^{*-1} \gamma_o C^{-1} = \gamma_5\gamma_\mu \quad . \qquad (8)$$

Now using condition (4) and its inverse we prove finally that Eq.(5) is a identity.

We can see from the previous discussion that the existence of a majorana tachyon is perfectly consistent with the present knowledge of the equations describing both kind of particles. However the implication of having a majorana tachyon for the rigth-handed neutrino are, from our point of view, more interesting. Actually since it is known from the literature on tachyon fields, these particles are disconnected from us. This means that in every process that we could consider at the subatomic level, these particles will not take up*.

The experimental consequence of this assumption would be the absence of rigth-handed currents. However, in this case we do not have restoration of parity at any scale. (We could still have restoration of parity if the γ_5 sign introduced in Eq.(1) is due to a dynamical effect at some energy scale.) This will put severe constriants on any kind of Grand Unified model we can think off.

On the other hand, it would be interesting having particles that travel faster than light under control. In order to see how this particles may interact with slower than ligth particles it is necessary to note that tachyons travel inside the horizontal light cone. If we make a rotation in the time-coordinate plane then we get tachyons from bradyons. In the four dimensional space-time we should have $(x, y, z, t) \rightarrow (t_x, t_y, t_z, X_t)$ under such transformation. A tachyon is a particle whith three time components in our world. At this point we are forced to ask: what is the meaning of having an extra time coordinate in our four dimensional space-time? Are we able to detect the extra time coordinate? In some theories it is often assumed that extra space dimensions can lead to internal degrees of freedom of the particles we observe. In the case of extra time dimensions I do not know for sure of the consequences for the particle behavior.

Answering some of the questions rised up to here would need more experimental facts in order to face them with the theoretical speculations.

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* In terms of measurements, observing a tachyon would mean measuring quantities which are imaginaries [3].