Relativistic Covariance vs. the Electroweak Theory

The following review article states that it is now recognized "that neutrinos can no longer be considered as massless particles" (see [1], p. 1307). It means that the neutrino is an ordinary massive Dirac particle which is described by a 4-component spinor. (The argument also applies to a Majorana neutrino.) This experimental evidence is inconsistent with the original structure of the Standard Model where "two-component left-handed massless neutrino fields play crucial role in the determination of the charged current structure of the Standard Model" [2]. In the following lines it is proved that a massive lepton is inconsistent with expressions that have the factor $(1 \pm \lambda\gamma^5)$, where λ is a numerical coefficient. The factor $(1 \pm \gamma^5)$ has been proposed for a two-component massless Weyl neutrino (see [3], p. 219, 367). The factor $(1 \pm \lambda\gamma^5)$ is used in a description of the electroweak theory of the an electron-neutrino interaction term (see e.g. [3], pp. 219, 220)

$$[\bar{\psi}_e \hat{O}(1 \pm \lambda\gamma^5)\psi_\nu]. \tag{1}$$

Here $\hat{O}$ represents an appropriate operator which operates on ψ_ν. It turns out that this expression does not hold for a massive Dirac neutrino. Indeed, operating with $(1 \pm \lambda\gamma^5)$ on a motionless spin-up Dirac spinor, one obtains

$$\begin{pmatrix} 1 & 0 & \pm\lambda & 0 \\ 0 & 1 & 0 & \pm\lambda \\ \pm\lambda & 0 & 1 & 0 \\ 0 & \pm\lambda & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ \pm\lambda \\ 0 \end{pmatrix}. \tag{2}$$

Here the notation of the γ matrices is that of [4], p. 17.

Let us examine the three cases where $|\lambda| > 1, |\lambda| = 1, |\lambda| < 1$.

- If $\lambda > 1$ then the right-hand side of (2) is a negative-energy Dirac spinor (see [4], pp. 28-30). It means that in this case the operator $(1 \pm \lambda\gamma^5)$ casts a massive motionless Dirac particle into an unphysical state.

- If $\lambda = 1$ then the right-hand side of (2) is a Dirac spinor that has an infinite energy-momentum (see [4], p. 30). It means that the operator $(1 \pm \gamma^5)$ casts a massive motionless Dirac particle into an unphysical state.

- $\lambda < 1$ then the right-hand side of (2) is a Dirac spinor that moves in the z-direction. The energy of this spinor is greater than that of the original motionless spinor. It follows that the operator $(1 \pm \lambda\gamma^5)$ does not commute with the Hamiltonian.

Conclusion: The Standard Model electroweak theory violates relativistic covariance.

Remark: The factor $(1 \pm \gamma^5)$ is used for adapting the Standard Model to the $\mathbf{V} - \mathbf{A}$ property of the weak interactions (see [3], pp. 217-220). The contradiction obtained above indicates that the Standard Model is inconsistent with the $\mathbf{V} - \mathbf{A}$ property of weak interactions.

For a further discussion, see [5].

References

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