Dirac Equation in Very Special Relativity and the Gyromagnetic Factor

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Introducción

Very Special Relativity (VSR) [1] is a theory where flat spacetime symmetries are reduced to a subgroup of the Lorentz group plus the spacetime translations, which it is kept unchanged. While its kynematical consequences are identical to the ones of special relativity [1], new non-classical consequences could arise. The original idea that motivated Cohen and Glashow to formulate VSR, for example, was a new mechanism for the emergence of Neutrino's masses [2].

In this work we consider the corrections arising from the SIM(2) invariant realization of Very Special Relativity to the energy spectrum of a $C-$invariant Dirac Fermion in a static and homogeneous magnetic field $\vec{B}$. First, we analyze the case of $\vec{B}$ parallel to the spatial VSR preferred direction $\vec{n}$, finding that the expression for the energy spectrum stays the same, except for a mass shift $m \to m_f = \sqrt{m^2 + M^2}$. Then, we relax the parallelism condition, finding a new equation for the energy spectrum. We solve this equation perturbatively. With a Penning trap's experiment in mind, we derive the first order VSR corrections to the electron's $g - 2$ factor. Finally, using the most accurate electron's g-factor measurements in Penning trap's experiments, we obtain an upper bound to the VSR electron mass parameter, and therefore also to the VSR electronic neutrino mass, of $1\, eV$.

Desarrollo

We start from the Modified VSR Dirac Equation in a fixed external magnetic field $\vec{B}$

$$\left(i\not{\partial} - e\not{A} - m + i\frac{M^2}{2}\not{N} \right) \psi(x) = 0\,, \tag{1}$$

such that the VSR operator is $N^\mu = \frac{n^\mu}{n\cdot(\partial + ieA)}$, with n^μ representing the preferred VSR light-like spacetime direction. From this we are able to find the perturbated energy spectrum in the general case, which, thinking of a trapped electron, can be related to the electron's gyromagnetic factor obtaining for its experimental-theoretical discrepancy

$$g_{exp} - g \sim -\mu \left[1 - \frac{11}{8}(2 - \frac{34}{11}\sin^2\theta)\epsilon \right] \sin^2\theta\,, \tag{2}$$

with $\mu = M/m_f$ and $\epsilon = eB/m_f^2$. Finally, considering the most up-to-date values of the theoretical and experimental value, we are able to give an upperbound to the VSR parameter of $\mu < 2{,}6 \times 10^{-12} \to M < 1eV$.

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Referencias

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