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Generation of Carroll-Field-Jackiw term in Horava-Lifshitz z=3 CPT-violating QED

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Theories with anisotropy between space and time, also called Horava-Lifshtiz (HL) theories, has been studied in many works since the seminal paper of P. Horava was published, where the Lifshitz scaling is used to construct a power counting renormalizable gravity model. The Lifshitz scaling is described by the transformation $x \to bx$, $t \to b^z t$, where the integer z is so-called critical exponent. In the case of quantum gravity, if $z = 3$, the dimension of gravitational constants turns out to be zero, a necessary condition for the renormalizability. Then, other theories started to be studied within the Horava-Lifshitz context, for example, theories with four fermion interaction and spinor QED.
An interesting problem to be studied is the HL-like theory where CPT symmetry is broken and the calculating the generation of a Carrol-Field-Jackiw (CFJ) term. The aim of this study could be the search for a generalized description of Lorentz breaking theories involving HL-like theories and where the 'usual' Lorentz-breaking theories as particular cases.

We start with the action of HL $z = 3$ CPT-violating QED where a Lorentz and CPT violating term is included in the fermionic sector
$S = \int d^4x \left[\bar{\psi}(i\not{D}_0 + (i\not{D}_i)^3 - m^3 - \not{b}_0\gamma_5 + (\not{b}\not{D}\not{D})_i\gamma_5)\psi\right]$,
where $\not{D}_0 = D_0\gamma^0$, $\not{D}_i = D_i\gamma^i$, $\not{b}_0 = b_0\gamma^0$, and $(\not{b}\not{D}\not{D})_i = (bDD)_{ijk}\gamma^i\gamma^j\gamma^k$, with
$D_{0,i} = \partial_{0,i} + ieA_{0,i}$.

To calculate the generated CFJ term, first we use the simplest prescription for Dirac matrices, where we find that the CFJ term is finite and reproduces one of the values obtained in the usual Lorentz-breaking QED
$\mathcal{L}_{CFJ} = -\frac{e^2}{4\pi^2} b_\kappa \epsilon^{\kappa\lambda\mu\nu} A_\lambda \partial_\mu A_\nu$.
Using the 't Hoft and Veltman prescription, we find that the CFJ term is not generated.
$\mathcal{L}_{CFJ} = 0$

So, we can conclude that the generated CFJ term is finite, and gauge and Lorentz invariant, but indetermined because of its dependence on the calculation scheme. This result is natural, because the chiral anomaly is related with the ambiguity of the triangle graph, and since the chiral anomalies also exist in $z = 3$ HL-QED, the presence of ambiguity in the triangle graph in our theory seems to be a direct analogy of the situation taking place in the usual Lorentz-breaking QED.

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