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Exploring Neutrinoless Double Beta Decay via Scalar Leptoquarks: Implications for Neutrino Mass and Flavor Physics

In this work, a detailed analysis of neutrinoless double beta ($0\nu\beta\beta$) decay in a radiative neutrino mass model involving scalar leptoquarks ($S_1(\bar{3},1,1/3)$ and $\widetilde{R}_2(3,2,1/6)$) is performed and the interplay with the low-energy flavor observables is highlighted. The leptoquark parameter space is constrained by the neutrino masses and mixings, collider limits, and various flavor measurements, including the anomalous magnetic moments of leptons, charged lepton flavor violations, and rare (semi) leptonic decays of kaons and B mesons, such as $R_{D^{(*)}}$ and $B \to K\nu\bar{\nu}$. The global analysis on the parameter space reveals that the most stringent constraints arise from $\mu \to e$ conversion in nuclei and $K^+ \to \pi^+\nu\bar{\nu}$ decay. A tension between muon and electron $(g-2)$ anomalies is also found in this framework. Incorporating leptoquark contributions to $0\nu\beta\beta$ decay, it is found that the cancellation region, seen in the standard light neutrino case for normal mass ordering can be removed and the effective Majorana mass ($m_{\beta\beta}$) can lie in the intermediate "desert" region between standard normal ordering and inverted ordering, which could be tested by future ton-scale experiments such as LEGEND-1000 and nEXO.

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