Lepton Flavor Violation in the Littlest Higgs Model with T-Parity ◇

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1. Introduction

Little Higgs models offer an alternative route to the solution of the so-called little hierarchy problem. One of the most attractive models of this class is the Littlest Higgs model [1] with T-parity (LHT) [2], where a discrete symmetry forbids tree-level corrections to electroweak observables. Especially the T-odd particles will have a substantial impact on deviations from the SM. The LHT model is based on a two-stage spontaneous symmetry breaking occurring at the scale f and the electroweak scale v. The additionally introduced gauge bosons, fermions and scalars are sufficiently light to be discovered at LHC. Moreover, the flavor structure of the LHT model is richer than the one of the Standard Model (SM), mainly due to the presence of three doublets of mirror quarks and leptons and their weak interactions with the ordinary quarks and leptons, as discussed in [3].

In the SM the FCNC processes in the lepton sector are very strongly suppressed due to tiny neutrino masses. A very different situation is to be expected in the LHT model, where the presence of new flavor violating interactions and of mirror leptons with masses of order 1 TeV can change the SM expectations up to 45 orders of magnitude, bringing the relevant branching ratios for lepton flavor violating (LFV) processes close to the bounds available presently or in the near future.

2. Lepton Flavor Violation in the LHT

In [4] an extensive analysis of LFV in the LHT model has been given. A detailed phenomenological analysis has been performed in that paper, paying particular attention to various ratios of LFV branching ratios that will be useful for a clear distinction of the LHT model from the MSSM. In order to see how large the LHT contributions can possibly be, it is useful to first consider those decays for which the strongest constraints exist. In this spirit we show in Fig. 1 the branching ratio $Br(\mu \to eee)$ as a function of $Br(\mu \to e\gamma)$, obtained from a general scan over the mirror lepton parameter space, with $f = 1$ TeV. It is found that in order to fulfill the present bounds, either the mirror lepton spectrum has to be quasi-degenerate or the $V_{H\ell}$ matrix must be very hierarchical. Moreover, even after imposing the constraints on $\mu \to e\gamma$ and $\mu \to eee$, the $\mu - e$ conversion rate in Ti is very likely to be found close to its current bound, and for some regions of the mirror lepton parameter space even violates this bound. The same is true for most branching ratios in the LHT model, in particular for low values of f, which makes these processes very interesting in view of new experiments taking place in this and the coming decade.

While the huge enhancements of LFV branching ratios possible in the LHT model are clearly interesting, such effects are common to many other NP models, such as the MSSM, and therefore cannot be used to distinguish these models. However, correlations between various branching ratios should allow a clear distinction of the LHT model from the MSSM. While in the MSSM [5] the dominant role in decays with three leptons in the final state and in $\mu - e$ conversion in nuclei is typically played by the dipole operator, in [4] it is found that this operator is basically irrelevant in the LHT model. This implies a striking difference between various ratios of branching ratios in the MSSM and in the LHT model. We like to point out that this procedure of comparing ratios and double ratios of branching ratios should be very useful in distinguishing these two models once enough LFV processes have been measured in low energy experiments.

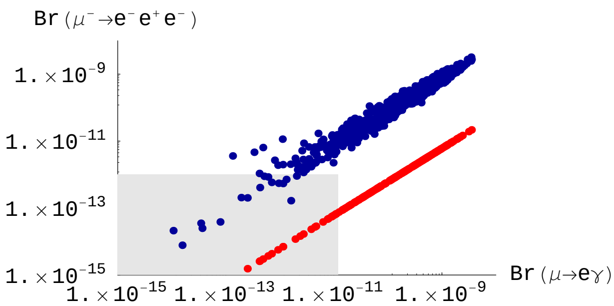

Fig. 1: Correlation between $Br(\mu \to e\gamma)$ and $Br(\mu \to eee)$ in the LHT model (upper curve) [4]. The lower line represents the dipole contribution to $\mu \to eee$ separately, which, unlike in the LHT model, is the dominant contribution in the MSSM.

The main messages from [4] are the following:

1. Most decay branching ratios can reach or even exceed the present experimental upper bounds even after the paramater space of the model has been constrained by the stringent upper bounds existing for $\mu \to e\gamma$ and $\mu \to eee$. This is especially the case for low values of the symmetry breaking scale f.

2. Ratios of branching ratios, for example $Br(\ell_i \to eee)/Br(\ell_i \to e\gamma)$, that are $\mathcal{O}(1)$ in the LHT but strongly suppressed in the MSSM, offer a clear distinction between these models. In this sense LFV decays are complimentary to high-energy processes studied at hadron machines like the LHC, where a distinction of this kind will be much more difficult.

References

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