Neutrino Masses and Lepton-Flavor Violation in a Supersymmetric Model with lopsided Froggatt - Nielsen charges

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Abstract

We analyze in detail lepton-flavor violation (LFV) in the charged-lepton sector, such as $\mu \to e\gamma$ and $\tau \to \mu\gamma$ within the framework of supersymmetric models with lopsided Froggatt–Nielsen charges. We show that the present experimental limits on the LFV processes already exclude some of the models. The proposed future search for LFV, especially in muon processes, can provide a significant probe to this framework.

Key words: lepton-flavor violation, lopsided mass matrix
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1 Introduction

Evidence of non-zero neutrino masses from atmospheric neutrino experiments has recently been announced by the Super-Kamiokande collaboration [1]. To understand this result, many models have been proposed [2]. Though there are various kinds of models, most of them can be interpreted in terms of the Froggatt–Nielsen (FN) mechanism [3], which uses a broken U(1) family symmetry. It has been proposed that lopsided FN U(1) charges for lepton doublets would be an interesting candidate to naturally account for the large mixing for neutrinos and the small mixings for quarks [2].

Here, we analyze the LFV in models with lopsided FN U(1) charges in detail. [1] We show that the search for LFV, especially in muon processes, provides a great impact on this framework, and even at present many of the models are

[1] The low-energy consequence in neutrino physics has been studied in Ref. [4].

almost excluded. We emphasize that the LFV search would be an important window to seek an answer to the fermion mass problem.

2 Models with lopsided Froggatt-Nielsen U(1)

We consider two types of lopsided FN U(1) charges for the left-handed lepton doublets, L_i ($i = 1$–3), listed in Table 1.

	$\mathbf{10}_1$	$\mathbf{10}_2$	$\mathbf{10}_3$	$\bar{\mathbf{5}}_1$	$\bar{\mathbf{5}}_2$	$\bar{\mathbf{5}}_3$	$\mathbf{1}_1$	$\mathbf{1}_2$	$\mathbf{1}_3$	H
Model I	2	1	0	$\tau+1$	τ	τ	c	b	a	0
Model II	3	1	0	τ	τ	τ	c	b	a	0

Table 1
Froggatt–Nielsen charges for matter and Higgs fields in SU(5) language.

The mass terms for the lepton sector are given by [2]

$$m_e \equiv \frac{f_e v \cos\beta}{\sqrt{2}} = \text{diag.}(e_1\epsilon^3,\ e_2\epsilon,\ e_3)\ \epsilon^\tau m_3, \tag{1}$$

$$M = \text{diag.}(n_1\epsilon^{2c},\ n_2\epsilon^{2b},\ \epsilon^{2a})\ M_R, \tag{2}$$

$$m_{\nu D} \equiv \frac{f_\nu v \sin\beta}{\sqrt{2}} = m_3\epsilon^\tau \begin{pmatrix} \bar{C}_3\epsilon^{c+\delta} & \bar{B}_3\epsilon^c & \bar{A}_3\epsilon^c \\ \bar{C}_2\epsilon^{b+\delta} & \bar{B}_2\epsilon^b & \bar{A}_2\epsilon^b \\ \bar{C}_1\epsilon^{a+\delta} & \bar{B}_1\epsilon^a & \bar{A}_1\epsilon^a \end{pmatrix}. \tag{3}$$

The coefficients (e_i, n_i, $\bar{A}_i$, $\bar{B}_i$, and $\bar{C}_i$) are undetermined, but, are expected to be of order 1 and $\delta = 0$ and 1 for Models I and II, respectively.

By randomly generating these coefficients so that these classes of models give experimentally allowed values for the masses and mixings, we can survey the consequences of these models for LFV processes.

3 Lepton-Flavor Violation

In the presence of non-zero neutrino Yukawa couplings, we can expect LFV phenomena in the charged-lepton sector through the RGE effect, even if we assume the universal scalar mass for all scalars at the GUT scale [5,6]:

[2] The charged-lepton and right-handed neutrino mass matrices are diagonalized.

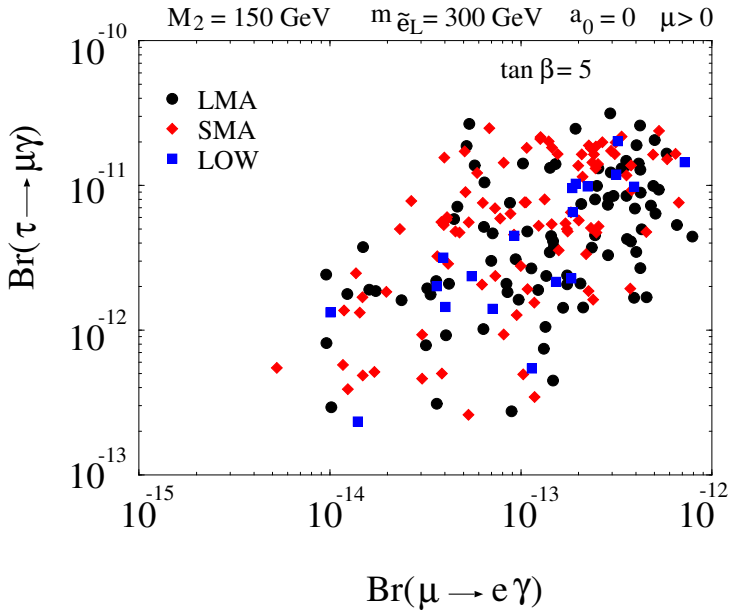

Fig. 1. $\mathrm{Br}(\mu \to e\gamma)$ versus $\mathrm{Br}(\tau \to \mu\gamma)$ in Model I with $(a, b, c, \tau) = (0, 1, 2, 1)$. Here, we take the left-handed slepton mass to be 300 GeV, the Wino mass to be 150 GeV, and $\epsilon = 0.07$.

$$\frac{d(m^2_{\tilde{L}})_{ij}}{d\log\mu} = \frac{1}{16\pi^2}\left[m^2_{\tilde{L}} f^\dagger_\nu f_\nu + f^\dagger_\nu f_\nu m^2_{\tilde{L}} + 2(f^\dagger_\nu m^2_{\tilde{\nu}} f_\nu + \tilde{m}^2_{H_u} f^\dagger_\nu f_\nu + A^\dagger_\nu A_\nu)\right]_{ij} \quad (4)$$

The prediction of the branching ratios in Model I ($\delta = 1$) with $(a, b, c, \tau) = (0, 1, 2, 1)$ is shown in Fig. 1. See ref [7] for predictions of other cases.

4 Conclusions

We discussed the neutrino masses and LFV in SUSY models with lopsided FN charges.

The present experimental limits on the LFV processes almost exclude those models with $\tau = 0$. In models with $\tau = 1$, the predicted branching ratios for $\tau \to \mu\gamma$ are as large as, or less than, 10^{-10}. In the very near future such processes will be observed.

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