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New Constraints on Gauged U(1)$_{L_\mu - L_\tau}$ Models via $Z - Z'$ Mixing

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It is known that the model based on U(1)$_{L_\mu - L_\tau}$ gauge symmetry can explain not only the discrepancy between the measured value of muon $g-2$ and the theoretical prediction, but also the structure of the neutrino mass and mixings. We revisit the analysis of the mass matrix structure in the minimal U(1)$_{L_\mu - L_\tau}$ models based on the latest experimental result, where the minimal stands for the symmetry breaking caused only by a single scalar field. We find that the model called type $\mathbf{2}_{+1}$, where an SU(2)$_L$ doublet scalar Φ_{+1} with the U(1)$_{L_\mu - L_\tau}$ charge $+1$ and the hypercharge $+1/2$, predicts the $\mathbf{B_3}$ texture and is marginally acceptable under the current neutrino oscillation data and cosmological observation. When the U(1)$_{L_\mu - L_\tau}$ gauge symmetry is broken by the vacuum expectation value of the standard model non-singlet representation such as Φ_{+1}, there are additional contributions to the flavor-changing meson decay process and atomic parity violation via the $Z - Z'$ mixing. We newly evaluate the model-dependent constraints on the model and conclude that the type $\mathbf{2}_{+1}$ model is robustly ruled out. The model is extended to have an additional vacuum expectation value of a standard model singlet scalar in order to avoid the stringent constraint from the flavor-changing meson decay. Finally, we find the allowed range of the ratio of these vacuum expectation values.

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