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How large can lepton mixing be?

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We show that, contrary to common expectations, the observed charged leptons can have a substantial mixing with new, heavier fermions. This can happen, in the language of effective theories, when the effect of mixing with heavier fermions vanishes at tree level in operators of mass-dimension 6 (or it is suppressed by the small charged lepton masses), a cancellation that can be naturally ensured by symmetries. Other observable effects from fermion mixing appear then, either at tree-level via operators of mass dimension 8, or at one-loop order in operators of mass-dimension 6.
Using a model that realizes this scenario we consider all current direct and indirect constraints and show that experimental constraints on the mixing are so mild that, given the current direct limit on the mass of the heavy fermions, theoretical considerations, mainly instability of the Higgs potential, presence of Landau poles and strong coupling, become the leading current constraints on the mixing.
Currently the right handed electron could have a 21% component of EW non-singlet and still be compatible with all current experimental and theoretical constraints. The equivalent limits for muons and taus are, respectively, 18% and 16%. Future experiments, including the high-luminosity of the LHC and, most notably, the FCC-ee, will be precise enough to make the experimental limits on the mixing surpase the theoretical ones.

Abstract

Primary author(s) : SÁNCHEZ LÓPEZ, Rafael (Universidad de Granada); Srta. GIULIANO, Chiara (Univeridad de Granada); SANTIAGO, Jose (Universidad de Granada); DE BLAS, Jorge (Universidad de Granada); Dr. GUEDES, Guilherme (CERN, Theoretical Physics Department)

Presenter(s) : SÁNCHEZ LÓPEZ, Rafael (Universidad de Granada)

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