- The EL model: Y^χ, X^χ and X^L must transform as $(1, 1+8)$, $(\bar{3}, 3)$ and $(1+8, 1)$, respectively. We thus have $Y^\chi \propto \mathbf{1}$, $X^\chi \propto Y^{E\dagger}$ and $X^L \propto \mathbf{1}$. This model does not give the correct mass hierarchy for the SM charged leptons unless we fine-tune either m_2 or M_1 to be negligibly small. We thus do not consider model EL any further.

B. Masses

The charged lepton mass matrix is a 6×6 Dirac mass matrix. The neutral lepton mass matrix is a 9×9 Majorana mass matrix. To obtain the mass eigenvalues and the mixing parameters we need to diagonalize these matrices. However, the hierarchies $m_2 \ll M_2$ and $y_\tau \ll 1$ allow us to obtain the main features straightforwardly. In particular, the spectrum of the heavy leptons is either quasi-degenerate (models EE and LL) or hierarchical, with hierarchy proportional to that of the light charged leptons (model LE). In order that we have at least one heavy lepton within the reach of the LHC, we take $M_2 \lesssim TeV$ for the quasi-degenerate models, and $y_e M_2 \lesssim TeV$ ($M_2 \sim 10^5\ TeV$) for the hierarchical model.

C. Decays

The leading decay modes of the heavy leptons would be two body decays into a light lepton and either the Higgs boson, or the Z-boson or the W-boson. Since the only lepton flavor violating spurion is Y^E, then, neglecting neutrino masses, there remains an exact lepton flavor symmetry,

$$G_{\rm LF} \to U(1)_e \times U(1)_\mu \times U(1)_\tau. \tag{2.5}$$

Each of the heavy lepton mass eigenstates thus decays into one, and only one light lepton flavor. This is the strongest prediction of our MLFV framework, and it provides the most crucial tests.

To find the relevant couplings of the heavy leptons, one has to obtain the interaction terms in the heavy lepton mass basis. However, the leading contributions and the most important features can again be understood on the basis of a straightforward spurion analysis. We first note that the decays will be dominantly into either the Higgs boson h or the longitudinal components of the vector bosons, ϕ_3 and $\phi_\pm$. Therefore, the decays are chirality changing. Furthermore, the $\chi_R \to E_L \phi$ transitions involve $SU(2)$-breaking and are therefore suppressed