1 $\mu \to e\gamma$ in LR symmetric model

We consider diagrams with W_R and W_L exchange. We include mixing between L-R W bosns, mixing between heavy-light neutrinos. We paramterize charged current interaction such that

$$\mathcal{L}_W = \frac{g}{\sqrt{2}}\overline{N}\left(K_R^R\gamma^\mu P_R + K_L^R\gamma^\mu P_L\right) l W_{R\mu}^+ \tag{1}$$

$$+ \frac{g}{\sqrt{2}}\overline{N}\left(K_R^L\gamma^\mu P_R + K_L^L\gamma^\mu P_L\right) l W_{L\mu}^+ \tag{2}$$

Typically K_R^R and K_L^L are large, while K_L^R and K_R^L are suppressed by L-R mixing.
Branching ratio for $\mu \to e\gamma$ is [1]

$$Br(\mu \to e\gamma) = \frac{3\alpha}{8\pi}\left|\sum_{h=L,R}\left(\frac{m_{W_L}}{m_{W_h}}\right)^2\sum_i\left[\left(K_R^{h\dagger}\right)_{ei}\left(K_R^h\right)_{i\mu}F\left(\frac{m_i^2}{m_{W_h}^2}\right) + \left(\frac{m_i}{m_\mu}\right)\left(K_L^{h\dagger}\right)_{ei}\left(K_R^h\right)_{i\mu}G\left(\frac{m_i^2}{m_{W_h}^2}\right)\right]\right|^2,$$

$$+\frac{3\alpha}{8\pi}\left|\left(\frac{m_W}{m_{W_R}}\right)^2\sum_i\left[\left(K_L^{h\dagger}\right)_{ei}\left(K_L^h\right)_{i\mu}F\left(\frac{m_i^2}{m_{W_h}^2}\right) + \left(\frac{m_i}{m_\mu}\right)\left(K_R^{h\dagger}\right)_{ei}\left(K_L^h\right)_{i\mu}G\left(\frac{m_i^2}{m_{W_h}^2}\right)\right]\right|^2$$

where m_i is the mass of the heavy neutrino. Function F is given by:

$$F(x) = \frac{1}{6\left(1-x\right)^4}\left[10 - 43x + 78x^2 - 49x^3 + 4x^4 + 18x^3\ln x\right]. \tag{3}$$

And function G is

$$G(x) = \frac{1}{\left(1-x\right)^3}\left[-4 + 15x - 12x^2 + x^3 + 6x^2\ln x\right]. \tag{4}$$

Sum over i runs over all six neutrinos. Light neutrino contribution is negligible, unless there is a large contribution due to the non unitarity of K_L.
For unitary K_R, ($\left(K_R^\dagger K_R\right)_{e\mu} = 0$) and for $\left(\frac{m_i}{m_{W_R}}\right) \ll 1$, assuming mixing only between two generations we get simplified equation

$$Br(\mu \to e\gamma) = \frac{3\alpha}{32\pi}\left(\frac{m_W}{m_{W_R}}\right)^4\left(\sin\theta\cos\theta\frac{\Delta m_{12}^2}{m_{W_R}^2}\right)^2. \tag{5}$$

Notice that the same equation holds also in the case of light neutrinos, if we put $m_{W_R} = m_W$. This contribution is negligible since

$$\frac{\Delta m_{12}^2}{m_W^2} \approx \frac{10^{-3}\mathrm{eV}^2}{80\mathrm{GeV}^2} \sim 10^{-25}. \tag{6}$$

For $M_{W_R} = 2200$GeV the branching ratio is suppressed by $\frac{3\alpha}{8\pi}\left(\frac{m_W}{m_{W_R}}\right)^4 \sim 10^{-9}$, which gives good estimation of the order of magnitude. To get an agreement with experimental bounds we need to adjust masses and mixing, such that $\left|\left[K_R^\dagger F\left(\frac{m_i^2}{m_{W_R}^2}\right)K_R\right]_{e\mu}\right|^2 \ll 1$. For unitary K_R the important suppression comes, not directly from the masses of neutrinos, but rather from the splitting of the masses. For maximal mixing between two generations, $M_{W_R} = 2200GeV$ and neutrinos masses at the scale of TeV, we need the splitting to be of the order of about 100GeV to get an agreement with the current bounds.
Based on [2] we get contribution form scalars $\Delta_{L,R}$

$$Br\left(\mu \to e\gamma\right) = \frac{\alpha}{48\pi G_F^2}\left[\frac{\left(f'^\dagger f'\right)_{\mu e}}{M_{\Delta^{++}}^2} + \frac{\left(f^\dagger f\right)_{\mu e}}{M_{\Delta^+}^2}\right]^2 \tag{7}$$

where we have assumed following interaction

$$\mathcal{L}_\Delta = l_L^T C^{-1} f l_L \Delta_L^{++} + l_R^T C^{-1} f l_R \Delta_R^{++} + \frac{1}{\sqrt{2}}\left(l_L^T C^{-1} f K_L^T v_L + v_L^T K_L f C^{-1} l_L\right)\Delta_L^+. \tag{8}$$

Also $f' = 2f$ for vertices with two identical particles. We usually denote $\Delta_L^+ = H_1^+$. Contribution form the H_2^+ is given by

$$Br\left(\mu \to e\gamma\right) = \frac{3\alpha}{4\pi}\frac{\sin^2 2\beta}{G_F^2\kappa^2 M_{H_2^+}^4 m_\mu^2}\left|\left(m_l f^T K_R^T M_N K_R\right)_{\mu e}\right|^2 \tag{9}$$

where $\beta = \frac{\kappa}{v_R}$. In a table we have summarized current and planned limits on various charged lepton flavor violating processes. Currently we need to focus on $\mu \to e\gamma$, which gives the best constrains. When we adjust the mixing, we also need to remember about τ CLFV decays. Other process will be important in future, but they also require significantly more work, since the direct contributions have to be evaluated. They usually require calculation of box diagrams. The best solution here would be to see if we can somehow combine our FeynRules implementation of LR model, with [3]. Unfortunately, for now our FeynRules output does not work properly with FeynArts, FormCalc.

Process	Current Limit	Planned Limit
$\tau \to \mu\gamma$	6.8E-8	1.0E-9
$\tau \to \mu\mu\mu$	3.2E-8	1.0E-9
$\tau \to eee$	3.6E-8	1.0E-9
$\mu \to e\gamma$	5.7E-13	1.0E-14
$\mu N \to eN$	7.0E-13	1.0E-17
$\mu \to eee$	1.0E-12	1.0E-16

Table 1: Current and planned limits on Lepton CFLV

References

[1] Jian-Ping Bu, Yi Liao, and Ji-Yuan Liu. Lepton Flavor Violating Muon Decays in a Model of Electroweak-Scale Right-Handed Neutrinos. *Phys. Lett.*, B665:39–43, 2008.

[2] R. N. Mohapatra. Rare decays of the tau lepton as a probe of the left-right symmetric theories of weak interactions. *Phys. Rev.*, D46:2990–2995, 1992.

[3] Werner Porod, Florian Staub, and Avelino Vicente. A Flavor Kit for BSM models. *Eur. Phys. J.*, C74(8):2992, 2014.