Lepton Flavour Violation in the Littlest Higgs Model with T-parity

Francisco del Águila

arXiv:1705.08827 [hep-ph]
There is a large literature, and excellent reviews, on Little Higgs models:

- M. Schmaltz, D. Tucker-Smith, hep-ph/0502182
- M. Perelstein, hep-ph/0512128
- J. Hubisz, P. Meade, A. Noble, M. Perelstein, hep-ph/0506042
- C.R. Chen, K. Tobe, C.P. Yuan, hep-ph/0602211

- Flavour anomalies discussion in the next three talks in Corfu 2017
Outline

• Motivation
  • No large Flavour Violating effects

• Model
  • Short review

• Lepton Flavour Violation in the LHT
  • Higgs decays
  • Gauge boson mediated processes

• Results

• Conclusions
### Upper Limits

<table>
<thead>
<tr>
<th>Process</th>
<th>Branching Ratio</th>
<th>Process</th>
<th>Branching Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu^- \rightarrow e^- \gamma$</td>
<td>$5.7 \times 10^{-13}$</td>
<td>$\mu^- \rightarrow e^- e^+ e^-$</td>
<td>$1.0 \times 10^{-12}$</td>
</tr>
<tr>
<td>Conversion Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu^- \rightarrow e^-$</td>
<td>$7.0 \times 10^{-13}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Branching Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau^- \rightarrow e^- \gamma$</td>
<td>$1.2 \times 10^{-7}$</td>
<td>$\tau^- \rightarrow \mu^- e^+ \mu^-$</td>
<td>$1.7 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^- \rightarrow \mu^- \gamma$</td>
<td>$4.5 \times 10^{-8}$</td>
<td>$\tau^- \rightarrow e^- \mu^+ e^-$</td>
<td>$1.5 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^+ \rightarrow e^+ \gamma$</td>
<td>$3.3 \times 10^{-8}$</td>
<td>$\tau^- \rightarrow \mu^- e^+ e^-$</td>
<td>$1.8 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^+ \rightarrow \mu^+ \gamma$</td>
<td>$4.4 \times 10^{-8}$</td>
<td>$\tau^- \rightarrow e^- \mu^+ \mu^-$</td>
<td>$2.7 \times 10^{-8}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\tau^- \rightarrow e^- e^+ e^-$</td>
<td>$2.7 \times 10^{-8}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\tau^- \rightarrow \mu^- \mu^+ \mu^-$</td>
<td>$2.1 \times 10^{-8}$</td>
</tr>
<tr>
<td>$Z \rightarrow \mu e$</td>
<td>$7.5 \times 10^{-7}$</td>
<td>$h \rightarrow \mu e$</td>
<td>$3.5 \times 10^{-4}$</td>
</tr>
<tr>
<td>$Z \rightarrow \tau e$</td>
<td>$9.8 \times 10^{-6}$</td>
<td>$h \rightarrow \tau e$</td>
<td>$6.1 \times 10^{-3}$</td>
</tr>
<tr>
<td>$Z \rightarrow \tau \mu$</td>
<td>$1.2 \times 10^{-5}$</td>
<td>$h \rightarrow \tau \mu$</td>
<td>$2.5 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

### LFV in LHT

- $\delta a_\mu \sim \frac{\alpha}{4\pi} \frac{m_\ell^2}{M^2_{WH}} \sim 10^{-11}$
- No tree level anomalies

\[
\frac{1}{16\pi^2} \frac{1}{f^2} \bar{l}_L \ell R \phi^+ \phi
\]

\[
\left| \frac{1}{16\pi^2} \frac{v^2}{f^2} \right|^2 \sim 10^{-7}
\]
• Little Higgs models stabilise the Standard Model (SM) Higgs doublet making it part of the Goldstone bosons associated with the breaking of a large enough global symmetry above the electro-weak scale $v \sim 246$ GeV. In the littlest case $SU(5)$ breaks down to $SO(5)$ at $f \sim$ few TeV.

• If the model can incorporate a $Z_2$ symmetry under which SM particles are even and the extra particles are odd, the latter must be pair produced and hence, their indirect effects are suppressed by at least one loop and the direct ones by the available energy -which must be larger than twice the lightest odd particle-.

• Such a discrete symmetry is realised in the Littlest Higgs model with T-parity (LHT). Hence, in this case Lepton Flavour Violating (LFV) amplitudes are suppressed by a factor $\frac{1}{16\pi^2} \frac{v^2}{f^2} \sim 4 \times 10^{-4}$. Smaller branching ratios can be accommodated allowing for small mixing angles.

• Previous studies of $\mu \rightarrow e \gamma$, $\mu \rightarrow e\bar{e}e$, $\mu N \rightarrow eN$ only include part of the T-odd spectrum. As recently noticed, Higgs decays are only one-loop finite if all T-odd particles are taken into account. What requires a reanalysis of all processes.
GLOBAL
\[ SU(5) \rightarrow SO(5) : \Sigma_0 = \begin{pmatrix} 0_{2\times2} & 0_{12\times2} \\ 0_{12\times2} & 0_{2\times2} \end{pmatrix} \]
\[ 24 = 14 + 10 \]

The matrix of the 14 Goldstone Bosons:

\[ \Pi = \]

\[
\begin{pmatrix}
-\frac{\omega^0}{2} - \frac{\eta}{\sqrt{20}} & -\frac{\omega^+}{\sqrt{2}} & -i\frac{\pi^+}{\sqrt{2}} & -i\Phi^{++} & -i\frac{\Phi^+}{\sqrt{2}} \\
-\frac{\omega^-}{\sqrt{2}} & \omega^0 - \frac{\eta}{\sqrt{20}} & \sqrt{\frac{4}{5}}\eta & -i\Phi^- & \frac{\omega^-}{\sqrt{2}} \\
i\frac{\pi^-}{\sqrt{2}} & v + h - i\pi^0 & \sqrt{\frac{4}{5}}\eta & -i\frac{\Phi^-}{\sqrt{2}} & \frac{\omega^-}{\sqrt{2}} \\
i\Phi^- & i\frac{\Phi^-}{\sqrt{2}} & \frac{\pi^-}{\sqrt{2}} & \frac{v + h - i\pi^0}{2} & -\frac{\omega^-}{\sqrt{2}} \\
i\frac{\Phi^-}{\sqrt{2}} & i\Phi^0 + \Phi^p & \frac{\pi^-}{\sqrt{2}} & \frac{v + h - i\pi^0}{2} & -\frac{\omega^-}{\sqrt{2}} \\
\end{pmatrix}
\]

All the other bosons \( T - \text{odd} \)

GAUGE
\[ SU(2)_1 \times U(1)_1 \times SU(2)_2 \times U(1)_2 \rightarrow SU(2)_{1+2} \times U(1)_{1+2} \]

\[ \gamma_H, Z_H, W^\pm_H \]

\[ \gamma, Z, W^\pm \]
LEPTONS PER FAMILY

Left – handed
\[ l_L = \frac{1}{\sqrt{2}} (l_{1L} - l_{2L}) \]
T – even (SM)
\[
\begin{pmatrix}
-i\sigma^2 l_{1L} \\
0 \\
0
\end{pmatrix}
\begin{pmatrix}
0 \\
0 \\
-i\sigma^2 l_{2L}
\end{pmatrix}
\begin{pmatrix}
-i\sigma^2 \bar{l}_c \\
-\chi_R \\
-\sigma^2 l_{HR}
\end{pmatrix}
T - even
\begin{pmatrix}
-i\sigma^2 \bar{l}_c \\
\chi_L \\
0
\end{pmatrix}
\]

Right – handed
\[ \ell_R \]
T – even (SM)

All the other leptons T – odd
Heavy masses $\sim f$

$$\mathcal{L}_{Y_H} = -\kappa f \left( \overline{\Psi}_2 \zeta + \overline{\Psi}_1 \Sigma_0 \zeta^\dagger \right) \Psi_R + \text{h.c.}$$

SM masses $\sim v$

$$\mathcal{L}_Y = \frac{i \lambda_\ell}{2\sqrt{2}} f \epsilon_{ij} \epsilon_{xyz} \left[ (\overline{\Psi}_2')_x \Sigma_{iy} \Sigma_{jz} X + \text{T-transformed} \right] \ell_R + \text{h.c.}$$

$$\Sigma(x) = e^{i\Pi/f} \Sigma_0 e^{i\Pi^T/f}$$

$$\Psi_2' = \begin{pmatrix} 0 \\ 0 \\ l_{2L} \end{pmatrix}, \quad X = (\Sigma_{33})^{-\frac{1}{4}}$$

Large masses

$$\mathcal{L}_M = -M \tilde{l}_R \tilde{l}_L + \text{h.c.}$$

H.C. Cheng, I. Low, hep-ph/0405243

F. del Águila, Corfu 2017
true for gauge boson mediated LFV processes where chiral symmetry allows for the guarantee that the partner lepton doublets have to be taken into account to obtain a finite result. This was charged diagrams (those exchanging heavy neutrinos) is finite. It is clear however from summing the entries of the last column, which adds to zero, the contribution of the as in Table

check explicitly. In Table

as in Table

The dots stand for the vanishing of the infinite and finite pieces of the corresponding gauge transitions \[ \frac{C^{(i)}_{\text{UV}}}{16\pi^2} + \frac{v^2}{f^2} C^{(v^2)}_{\text{UV}} \left( \frac{1}{\epsilon} \sum_{i=1}^{3} V_{\ell'^{\prime} i} V_{i \ell} \frac{m_{\ell'}^2}{f^2} H^i \bar{u}(p', m_{\ell'}) \left( \frac{m_{\ell'}}{v} P_L + \frac{m_{\ell}}{v} P_R \right) v(p, m_{\ell}) \right) \]

\begin{array}{c|cccccccc|c}
\hline
C^{(i)}_{\text{UV}} & \text{I} & \text{II} & \text{III} & \text{IV} & \text{V+VI} & \text{VII+VIII} & \text{IX+X} & \text{XI+XII} & \text{Sum} \\
\hline
\omega, \nu_H & - & - & \bullet & - & - & - & 1 & -1 & \bullet \\
\omega^0, \ell_H & - & - & \bullet & - & - & - & 1/2 & -1/2 & \bullet \\
\eta, \ell_H & - & - & \bullet & - & - & - & 1/10 & -1/10 & \bullet \\
\text{Total} & - & - & \bullet & - & - & - & 8/5 & -8/5 & \bullet \\
\hline
\end{array}

Table 6. Divergent contributions proportional to $\frac{1}{\epsilon}$, with $\epsilon = 4 - d$ the extra dimensions in dimensional regularization, of each particle set running in the loop and topology in Figure 1 contributing at $O(1)$. A dash means that the field set does not run in the diagram, whereas a dot indicates that the infinite and finite parts vanish.
\[
C_{UV}^{(\frac{v^2}{f^2})}
\]

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V+VI</th>
<th>VII+VIII</th>
<th>IX+X</th>
<th>XI+XII</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(W_H, \nu_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(W_H, \omega, \nu_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\omega, \nu_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(Z_H, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(Z_H, \omega^0, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\omega^0, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(A_H \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(A_H, \eta, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\eta, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(Z_H, A_H, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\omega^0, \eta, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(W_H, \Phi, \nu_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\Phi, \nu_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\omega, \Phi, \nu_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\omega^0, \Phi^P, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\eta, \Phi^P, \ell_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\Phi, \tilde{\nu}^c, \nu_H)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7. As in Table 6 but to \(O(v^2/f^2)\). \(x_H = \frac{5t_W}{4(5-t_W^2)}\) is defined in Eq. (2.33) with \(t_W = \frac{s_W}{c_W}\).
\[ \mathcal{L}_{\text{eff}} = -\frac{\sqrt{2}}{v} m_{\ell_i} \bar{L}_i \phi \ell_R + \frac{c_{ij}}{f^2} |\phi|^2 \bar{L}_i \phi \ell_R + \text{h.c.} + \ldots \]

\[
= \left[ \left( -m_{\ell_i} \delta_{ij} + \frac{1}{2\sqrt{2}} \frac{v^3}{f^2} c_{ij} \right) \frac{h}{v} \left( -m_{\ell_i} \delta_{ij} + \frac{3}{2\sqrt{2}} \frac{v^3}{f^2} c_{ij} \right) \right] \tilde{\ell}_L \ell_R + \text{h.c.} + \ldots,
\]

\[
= \frac{c_{ij} v}{2\sqrt{2}} + (A_L)_{ij} m_{\ell_j} - m_{\ell_i} (A_R)_{ij} = 0, \quad (i \neq j, \text{ physical basis})
\]

\[
= \frac{v^2}{f^2} \left[ \frac{3 c_{ij}}{2\sqrt{2}} + (A_L)_{ij} \frac{m_{\ell_j}}{v} - \frac{m_{\ell_i}}{v} (A_R)_{ij} \right] h \tilde{\ell}_L \ell_R + \ldots
\]

\[
= \frac{1}{\sqrt{2}} \frac{v^2}{f^2} c_{ij} h \tilde{\ell}_L \ell_R + \ldots, \quad (i \neq j, \text{ physical basis})
\]
Figure 1: Topologies contributing to $\gamma, Z \rightarrow \ell\ell'$.
of the new extra lepton doublets and the pseudo-Goldstone sc

Table I: Divergent contributions proportional to ξI and ξII, are absent. A dash means that the field set does not r

finite but the

subset (row). In the second table the total sum is zero, which

is non-vanishing. The upper half of this table

boson contributing to

Total

Total

Table II: As in Table I but to \( O(\frac{v^2}{f^2}) \). \( y_H = \frac{1-t_W}{8(5-t_W)} \) with \( t_W = \frac{s_W}{c_W} \).


arXiv:0809.4753[hep-ph]

\[ F_L^Z = F_L^Z|_{W_H} + F_L^Z|_{A_H} + F_L^Z|_{Z_H} + F_L^Z|_{\tilde{\nu}^c} + F_L^Z|_{\tilde{\ell}^c} \]

\[
= \sum_i V_{\ell'i} V_{i\ell} \frac{\alpha_W}{8\pi s_W c_W} \left\{ \frac{v^2}{8f^2} H_L^{W(0)} \left( \frac{m_{\ell_Hi}^2}{M_{WH}^2} \right) + \frac{Q^2}{M_{WH}^2} H_L^W \left( \frac{m_{\ell_Hi}^2}{M_{WH}^2} \right) \right\} \\
+ (1 - 2c_W^2) \frac{Q^2}{M_{WH}^2} \left[ \frac{1}{5} H_L^{A/2} \left( \frac{m_{\ell_Hi}^2}{M_{AH}^2} \right) + H_L^{A/2} \left( \frac{m_{\ell_Hi}^2}{M_{ZH}^2} \right) \right] \\
+ \sum_{ijk} V_{\ell'i} \frac{m_{\ell_Hi}}{M_{WH}} V_{i\ell} \frac{m_{\ell_Hk}}{M_{WH}} V_{k\ell} \frac{\alpha_W}{8\pi s_W c_W} \frac{Q^2}{M_\Phi^2} \left[ H_L^{\tilde{\nu}} \left( \frac{m_{\tilde{\nu}_j}^2}{M_\Phi^2} \right) + (1 - 2c_W^2) H_L^{\tilde{\ell}} \left( \frac{m_{\tilde{\ell}_j}^2}{M_\Phi^2} \right) \right] \]

-- Linear --

-- Inverse --

-- Constant --
\[
\theta_W = 0
\]

\[
\theta_W = 0
\]

\[
\delta a_\mu
\]

\[
B(\mu \to e\gamma)
\]

\[
B(\mu \to e\bar{e}e)
\]

\[
R(\mu \to e) \text{ in Ti}
\]

\[
R(\mu \to e) \text{ in Au}
\]

\[
B(Z \to \mu e)
\]

\[
B(h \to \mu e)
\]

\[
\exp\{\delta a_\mu\}
\]

\[
\theta_W = 0
\]

\[
\theta_W = 0
\]

\[
\theta_W = 0
\]

\[
\theta_W = 0
\]

\[
\frac{\text{Ratio to current limits}}{\theta_W = 0}
\]

\[
\frac{\text{Ratio to current limits}}{\theta_W = 0}
\]

\[
\frac{\text{Ratio to current limits}}{\theta_W = 0}
\]

\[
\frac{\text{Ratio to current limits}}{\theta_W = 0}
\]
\[ \theta_W = 0 \]

\[ \exp\{\delta a_\mu\} \]

\[ B(\mu \to e\gamma) \]

\[ B(\mu \to e\varepsilon\bar{\varepsilon}) \]

\[ R(\mu \to e) \text{ in Ti} \]

\[ R(\mu \to e) \text{ in Au} \]

\[ B(Z \to \mu e) \]

\[ B(h \to \mu e) \]

\[ (\text{TeV}^2) m_{H1}m_{H2} = \tilde{x} \]

\[ \theta_W = 0 \]

\[ \exp\{\delta a_\mu\} \]

\[ B(\mu \to e\gamma) \]

\[ B(\mu \to e\varepsilon\bar{\varepsilon}) \]

\[ R(\mu \to e) \text{ in Ti} \]

\[ R(\mu \to e) \text{ in Au} \]

\[ B(Z \to \mu e) \]

\[ B(h \to \mu e) \]

\[ \theta_W = 0 \]

\[ \exp\{\delta a_\mu\} \]

\[ B(\mu \to e\gamma) \]

\[ B(\mu \to e\varepsilon\bar{\varepsilon}) \]

\[ R(\mu \to e) \text{ in Ti} \]

\[ R(\mu \to e) \text{ in Au} \]

\[ B(Z \to \mu e) \]

\[ B(h \to \mu e) \]

\[ \theta_W = 0 \]

\[ \exp\{\delta a_\mu\} \]

\[ B(\mu \to e\gamma) \]

\[ B(\mu \to e\varepsilon\bar{\varepsilon}) \]

\[ R(\mu \to e) \text{ in Ti} \]

\[ R(\mu \to e) \text{ in Au} \]

\[ B(Z \to \mu e) \]

\[ B(h \to \mu e) \]
### Upper Limits

<table>
<thead>
<tr>
<th>Process</th>
<th>Branching Ratio</th>
<th>Process</th>
<th>Branching Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu^- \to e^-\gamma$</td>
<td>$5.7 \times 10^{-13}$</td>
<td>$\mu^- \to e^-e^+e^-$</td>
<td>$1.0 \times 10^{-12}$</td>
</tr>
<tr>
<td>$\mu^- \to e^-$</td>
<td>$7.0 \times 10^{-13}$</td>
<td>$\tau^- \to \mu^-e^+\mu^-$</td>
<td>$1.7 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^- \to e^-\gamma$</td>
<td>$1.2 \times 10^{-7}$</td>
<td>$\tau^- \to e^-\mu^+e^-$</td>
<td>$1.5 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^- \to \mu^-\gamma$</td>
<td>$4.5 \times 10^{-8}$</td>
<td>$\tau^- \to \mu^-e^+e^-$</td>
<td>$1.8 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^+ \to e^+\gamma$</td>
<td>$3.3 \times 10^{-8}$</td>
<td>$\tau^- \to e^-\mu^+\mu^-$</td>
<td>$2.7 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^+ \to \mu^+\gamma$</td>
<td>$4.4 \times 10^{-8}$</td>
<td>$\tau^- \to e^-e^+e^-$</td>
<td>$2.7 \times 10^{-8}$</td>
</tr>
<tr>
<td>$\tau^- \to \mu^-\mu^+\mu^-$</td>
<td>$2.1 \times 10^{-8}$</td>
<td>$Z \to \mu e$</td>
<td>$7.5 \times 10^{-7}$</td>
</tr>
<tr>
<td>$Z \to \tau e$</td>
<td>$9.8 \times 10^{-6}$</td>
<td>$h \to \mu e$</td>
<td>$3.5 \times 10^{-4}$</td>
</tr>
<tr>
<td>$Z \to \tau \mu$</td>
<td>$1.2 \times 10^{-5}$</td>
<td>$h \to \tau e$</td>
<td>$6.1 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

*Conversion Rate*

$$16 \pi^2 \frac{v^2}{m_Z^2} \sim 25\%$$

$$\frac{1}{16 \pi^2} \frac{1}{f^2} \left| \bar{L}_\ell \phi \ell_R \phi^+ \right|^2 \sim 10^{-7}$$

$$\delta a_\mu \sim \frac{\alpha}{4\pi} \frac{m_\ell^2}{M_{WH}^2} \sim 10^{-11}$$

No tree level anomalies
• The Littlest Higgs model with T-parity allows for a lower scale of new physics because the new T-odd particles must be produced by pairs and then, they contribute to SM processes only at loop order. Thus, for example, LFV amplitudes are suppressed by a factor $(1/16\pi^2)\, v^2/f^2 \sim 10^{-7}$.

• In order to keep Higgs amplitudes finite at one loop, all the T-odd spectrum must run in the loop, implying that all T-odd particles must have masses $\sim f$. In general, however, in definite processes some contributions may vanish (decouple) if the exchanged T-odd particles have masses going to infinity.

• LFV processes are one-loop finite in the LHT. Branching ratios $< 10^{-7}$ can be accommodated allowing for small mixing angles and/or correlated heavy masses.
Thanks for your attention