A predictive SO(10) scenario for leptogenesis and flavour violation

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based on:
• L. Calibbi, M. Frigerio, S.L. and A. Romanino, to appear

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Introduction

The (type I) seesaw mechanism nicely connects neutrino masses and the baryon asymmetry of the Universe:

- light neutrino masses through the exchange of heavy right-handed neutrinos

\[
(M_{\nu})_{\alpha\beta} = -\sum_{i} \frac{Y_{i\alpha}Y_{j\beta}}{M_i} \nu^2
\]

- baryon asymmetry through their out-of-equilibrium decays (leptogenesis)

\[
\epsilon_{N_1} \equiv \frac{\Gamma(N_1 \to LH) - \Gamma(N_1 \to \bar{L}H^*)}{\Gamma(N_1 \to LH) + \Gamma(N_1 \to \bar{L}H^*)} \approx \frac{3}{16\pi} \sum_{k} \frac{\text{Im}[(YY^\dagger)_k]_1}{(YY^\dagger)_1} \frac{M_k}{M_1}
\]

But difficult to test:

- right-handed neutrinos too heavy to be produced
- in general no direct connection between the CP asymmetry and low-energy observables (18 seesaw parameters for 9 low-energy parameters, \(m_i\) and \(U_{PMNS}\))
In the Susy case, the RHN couplings induce flavour-violating entries in the slepton mass matrices ⇒ lepton-flavour violating (LFV) processes like $\mu \rightarrow e \gamma$  
[Since the image contains a diagram, it is not transcribed here.]

But no obvious correlation: LFV and leptogenesis depend on different combinations of the seesaw parameters

Type II seesaw mechanism more predictive:

$\Delta = SU(2)_L$ triplet with couplings $f_{\alpha \beta}$ to lepton doublets

$$ (M_\nu)_{\alpha \beta} = \frac{\lambda_H v^2}{2M_\Delta} f_{\alpha \beta} $$

⇒ the triplet-induced LFV is controlled by the light neutrino parameters  [A. Rossi]

Triplet leptogenesis also possible, but to get a non-vanishing CP asymmetry need another heavy state with couplings $g_{ij} \neq f_{ij}$ to lepton doublets ⇒ direct connection with low-energy parameters lost

$$ \epsilon_\Delta \propto \text{Im} \left[ \text{Tr} \left( M_\nu^{(\Delta)\dagger} M_\nu^{(H)} \right) \right] \quad M_\nu = M_\nu^{(\Delta)} + M_\nu^{(H)} $$  [Hambye, Raidal, Strumia]

However, such a connection can be recovered if the type II seesaw mechanism is realized in a SO(10) GUT
Type II seesaw in non-standard SO(10) unification

Not easy to avoid the type I contribution: RHNs belong to the matter representation (16), hence are always around and couple to lepton doublets

Way out: “non-standard” embedding of the SM fermions into SO(10) representations

\[
16_i = 10_i \oplus \cdots \oplus 1_i \\
10_i = \cdots \oplus \bar{5}^{10}
\]

\((\bar{5}^{10}_i, \bar{5}^{16}_i)\) form a (heavy) vector-like pair of matter fields

Motivation: E6? \(27_i = 16_i \oplus 10_i \oplus 1_i\)

How to achieve this? \(W = \frac{1}{2} y_{ij} 16_i 16_j 10 + h_{ij} 16_i 10_j 16\)

SU(5) singlet in the 16: \(V_1^{16} \neq 0 \Rightarrow\) GUT-scale masses for \((\bar{5}^{10}_i, \bar{5}^{16}_i)\)

\(5^{10}_i \equiv (L^c_i, D_i)\) heavy anti-lepton doublets and quark singlets

SM matter fields: \(10^{16}_i = (Q_i, u^c_i, e^c_i), \quad \bar{5}^{10}_i \equiv (L_i, d^c_i), \quad 1^{16}_i = \nu_i^c\)
Quark and lepton masses:

\[ W = \frac{1}{2} y_{ij} 16_i 16_j 10 + h_{ij} 16_i 10_j 16 \]

No neutrino Dirac couplings at tree level: RHNs couple to heavy leptons

The heavy leptons (quarks) have hierarchical masses proportional to down-type fermion masses:

\[ M_i = h_i V_1^{16} = m_{e_i} V_1^{16} / v_1^{16} \]

Neutrino masses:

\[ W_{II} = \frac{1}{2} f_{ij} 10_i 10_j 54 + \frac{1}{2} \sigma 10 10 54 + \frac{1}{2} M_{54} 54^2 \]

\[ \Rightarrow \frac{1}{2} f_{ij} L_i L_j \Delta + \frac{1}{2} \sigma H_u^{10} H_u^{10} \bar{\Delta} + M_{\Delta} \Delta \bar{\Delta} + \ldots \]

where \( 54 = 15 \oplus \overline{15} \oplus 24 \), \( 15 = (\Delta, Z, \Sigma) \), \( \Delta = (1, 3)_{+2} \)

\[ \Rightarrow \text{type II seesaw:} \quad M_{\nu} = \frac{\sigma (v_1^{10})^2}{2M_{\Delta}} f \]

Assumed:
- matter parity
- no mass term \( 10_i 10_j \), no 54 vev \( \Rightarrow \) no mixing \( \overline{5_i}^{10} / \overline{5_i}^{16} \)
Leptogenesis

Requires a CP asymmetry in triplet decays. In standard triplet leptogenesis, the f_{ij}’s are not enough: need a second set of (flavour) couplings, otherwise
\[ \epsilon_\Delta \propto \text{Im}[\text{Tr}(f f^* f f^*)] = 0 \]

⇒ introduce e.g. a second triplet with couplings g_{ij} \neq f_{ij} to leptons

⇒ lose predictivity: no direct connection between leptogenesis and low-energy parameters (as in type I case: see e.g. Davidson et al, Petcov et al.)

However, in our scenario the states in the loop are heavy:

(\text{the self-energy diagram does not contribute to the asymmetry})
The $\tilde{L}_i^c$ are heavy with hierarchical masses:

$$(M_1, M_2, M_3) \sim (2 \times 10^{11}, 4 \times 10^{13}, 7 \times 10^{14}) \text{ GeV} \left( \frac{\tan \beta}{10}\right) \left( \frac{V_{16}}{10^{16} \text{ GeV}} \right)$$

If e.g. $M_3 > M_\Delta/2$, the trace is incomplete and $\epsilon_\Delta \neq 0$

Assuming $M_1 \ll M_\Delta < M_1 + M_2$ and $M_S = M_T = M_{24} \gg M_\Delta$ gives

$$\epsilon_\Delta \simeq \frac{1}{10\pi} \frac{M_\Delta}{M_{24}} \left( \frac{V_{16}}{10^{16} \text{ GeV}} \right)^2 \left( \frac{\tan \beta}{10}\right) \lambda_2^L + \lambda_2^{L_1^c} + \lambda_2^{H_u} + \lambda_2^{H_d} \frac{\text{Im}[M_{11}(M^* M M^*)_{11}]}{(\sum_i m_i^2)^2}$$

with $\lambda_2^L \equiv \sum_{i,j=1}^3 |f_{ij}|^2$, $\lambda_2^{L_1^c} \equiv |f_{11}|^2$, $\lambda_2^{H_u,d} \equiv |\sigma_{u,d}|^2$

$\Delta_s \rightarrow \tilde{L}_1^c \tilde{L}_1^c$: opposite CP asymmetry ($-\epsilon_\Delta$) / $\Delta_s \rightarrow \tilde{H}_d \tilde{H}_d, H_u H_u$: no CP asymmetry
Dependence on the light neutrino parameters

\[
\frac{\text{Im}[M_{11}(M^* M M^*)_{11}]}{m^4} = - \frac{1}{m^4} \left\{ c_{13}^2 c_{12} s_{12}^2 \sin(2\rho) m_1 m_2 \Delta m_{21}^2 
+ c_{13}^2 s_{13}^2 c_{12}^2 \sin 2(\rho - \sigma) m_1 m_3 \Delta m_{31}^2 
- c_{13}^2 s_{13}^2 s_{12}^2 \sin(2\sigma) m_2 m_3 \Delta m_{32}^2 \right\}
\]

\[U_{ei} = (c_{13} c_{12} e^{i\rho}, c_{13} s_{12}, s_{13} e^{i\sigma})\]

→ \(\epsilon_\Delta\) does not depend on high-scale flavour parameters - only on the light neutrino parameters and on \(\lambda_L, \lambda_{H_u}, \lambda_{H_d}, M_\Delta/M_{24}\)

→ the CP violation needed for leptogenesis is provided by the CP-violating phases of the PMNS matrix

\[\text{[the Majorana phases } \rho \text{ and } \sigma \text{ in the case } M_1 < M_\Delta < M_1 + M_2]\]

→ \(\epsilon_\Delta\) can be large (\(\lambda_L^2\) is bounded by perturbativity):

\[
\begin{align*}
\epsilon_\Delta^{\text{max}} &\approx 2.2 \times 10^{-4} \lambda_L^2 & \text{(maximum } \theta_{13}) , \\
&\approx 3.4 \times 10^{-5} \lambda_L^2 & \text{(vanishing } \theta_{13}) ,
\end{align*}
\]
Isocontours of the CP asymmetry in units of $\lambda_L^2$ in the $(\sin^2 \theta_{13}, m_{\text{lightest}})$ plane, maximized with respect to the CP-violating phases and to $M_\Delta/M_{24}$
$\frac{nB}{s} = 7.62 \times 10^{-3} \eta \epsilon_\Delta$ agrees with the WMAP value $(8.82 \pm 0.23) \times 10^{-11}$

if $\eta \epsilon_\Delta \approx 10^{-8}$ \Rightarrow the efficiency factor $\eta$ can be as small as $10^{-5} - 10^{-4}$
in the region where the CP asymmetry is maximal

This regime must be studied numerically. There is also a large efficiency regime that can be discussed analytically, where

$$K_{L_i^c} \ll 1 \quad \text{and} \quad K_L, K_{H_u} \gtrsim 1$$

with $K_a \equiv \Gamma(\Delta \rightarrow aa) / H(M_\Delta) \quad (a = \tilde{L}_{i}^c, \tilde{L}, H_u)$

Even though triplet decays are in equilibrium, a large lepton asymmetry is generated thanks to $K_{L_i^c} \ll 1$ and $\eta \sim 1$ can be obtained [Hambye, Raidal, Strumia]

[the CP asymmetry in the channel $\Delta \rightarrow \tilde{L}_{1}^c\tilde{L}_{1}^c$ is $-\epsilon_\Delta$]

The condition $K_{L_i^c} \ll 1$ tends to suppress the CP asymmetry, which can be compensated for by increasing the triplet mass
schematically:

At $T < M_\Delta$, decays start to dominate over gauge scatterings $\Delta \Delta^* \rightarrow \cdots$

Since $K_L, K_{H_u} \gtrsim 1$, triplets keep close to thermal equilibrium but a $\tilde{L}_1^c$ asymmetry develops due to $K_{\tilde{L}_1^c} \ll 1$

This in turn induces an asymmetry between triplets and antitriplets, which transferred to $\Delta_L$ and $\Delta_{H_u}$ through their decays

The final B–L asymmetry then reads:

$$Y_{B-L} \simeq \frac{Y_{eq}^{H_u}}{Y_{eq}^L + Y_{eq}^{H_u}} \Delta_{\tilde{L}_1^c} = \frac{4}{7} \Delta_{\tilde{L}_1^c}$$

where $\Delta_{\tilde{L}_1^c} = \eta_0 \epsilon_\Delta (Y_{\Delta}^{eq} + Y_{\Delta^*}^{eq}) (T \gg M_\Delta)$

and $\eta_0 \sim 1$ due to $\gamma_A \ll \gamma_D$ and $K_{\tilde{L}_1^c} \ll 1$
Normal hierarchy with $m_1 \ll m_2$, $\sin^2 \theta_{13} = 0.05$ and $\sin 2 \sigma = 1$.

$\tan \beta = 10$, $\lambda_{H_d} = 0$ and $M_{\Delta}/M_{24} = 0.1$.
In the large efficiency regime, successful leptogenesis requires:

- a normal light neutrino hierarchy
- a large value of $\theta_{13}$
- large Majorana phases

→ the scenario can be excluded on the basis of neutrino experiments!
We find that successful leptogenesis is possible for $M_\Delta \gtrsim 10^{12}$ GeV.

This scale is problematic in view of the gravitino problem, which requires $T_{RH} \lesssim (10^9 - 10^{10})$ GeV in the most favourable cases (unstable gravitino with $m_{3/2} \gtrsim 10$ TeV or gravitino LSP with harmless NLSP for BBN).

**Ways out:**

- very light gravitino (< 16 eV required by WMAP)
- very heavy gravitino (>> 100 TeV)
- non-thermal production of the triplets ($T_{RH} \ll M_\Delta$)
- non-supersymmetric scenario with a real 54

In the following, we consider a supersymmetric scenario with soft terms generated at the GUT scale, and we rely on possibility 2 or 3.
Predictions for flavour violation

The squark and slepton soft terms receive flavour-violating radiative corrections from:

- the heavy triplets and their SO(10) partners (components of the 54) ⇒ controlled by the $f_{ij} \, (f_{ij\,10_i\,10_j\,54})$
- the heavy quarks and leptons (heavy components of the 16i and 10i) ⇒ controlled by the up-quark Yukawa couplings ($y_{ij\,16_i\,16_j\,10}$)

→ flavour structure of the radiative corrections predicted in terms of low-energy parameters [up quark and neutrino masses, quark and lepton mixing]

Their absolute size also depends on a few high-energy parameters [ $\lambda_H$, masses of the 54 components, absolute scale of the heavy quarks and leptons fixed by $V_{16}^{16} / \sin \theta_H$, where $\theta_H$ is defined by $H_d^{light} = \sin \theta_H H_d^{16} + \cos \theta_H H_d^{10}$ ]

Also mild model dependence associated with the non-renormalizable operators needed to correct the mass relation $M_d = M_e^T$ : in general spoil the relation between the heavy and light down quark/charged lepton mass matrices. However the dependence on the heavy masses is logarithmic
Assuming universal soft terms at the GUT scale, we obtain in the leading-log approximation (in matrix form):

$$\delta m_L^2 = -\frac{3m_0^2 + A_0^2}{16\pi^2} f^\dagger \left( 3 \ln \frac{M_{GUT}^2}{M_{15}^2} + \frac{9}{10} \ln \frac{M_{GUT}^2}{M_{24}^2 + M_{Lc}^T M_{Lc}^*} + \frac{3}{2} \ln \frac{M_{GUT}^2}{M_{24}^2 + M_{D}^T M_{D}^*} \right) f$$

$$\delta m_{dc}^2 = -\frac{3m_0^2 + A_0^2}{16\pi^2} f^\dagger \left( 3 \ln \frac{M_{GUT}^2}{M_{15}^2} + \ln \frac{M_{GUT}^2}{M_{24}^2 + M_{Lc}^\dagger M_{Lc}^*} + \frac{7}{5} \ln \frac{M_{GUT}^2}{M_{24}^2 + M_{D}^\dagger M_{D}^*} \right) f$$

The first term in the bracket is present in the SU(5) version of the type II seesaw [A. Rossi], the next two are due to the presence of the heavy quarks and leptons.

Contrary to the standard type II seesaw, flavour violation is also induced in the singlet slepton and doublet squark sectors:

$$\delta m_{ec}^2 = -\frac{3m_0^2 + A_0^2}{16\pi^2} \cos^2 \theta_H y^\dagger \left( 2 \ln \frac{M_{GUT}^2}{M_{Lc}^* M_{Lc}^*} \right) y$$

$$\delta m_Q^2 = -\frac{3m_0^2 + A_0^2}{16\pi^2} \cos^2 \theta_H y^\dagger \left( \ln \frac{M_{GUT}^2}{M_{D}^* M_{D}^*} \right) y$$

$\delta m_Q^2$ has the same flavour structure as the MSSM radiative corrections.
The intermediate pair of Higgs doublets spoils gauge coupling unification. This can be cured by splitting the components of the $15 \oplus \overline{15}$ and 24 SU(5) multiplets inside the 54 (which also has the advantage of keeping unification perturbative). 2 possibilities emerge (both with $M_H = 10^{14}$ GeV and $M_T / M_\Delta = 10$, motivated by leptogenesis):

(i) all components of the 54 have GUT-scale masses but $(\Delta, \bar{\Delta}), (\Sigma, \bar{\Sigma})$ and $T$ (with $M_\Sigma = M_\Delta$ and $M_T / M_\Delta = 10$ fixed)

(ii) all components of the 54 have GUT-scale masses but $(\Delta, \bar{\Delta}), (\Sigma, \bar{\Sigma}), S, T$ and $O$ (with $M_\Delta < M_\Sigma$, $M_S = M_T = M_O$ and $M_T / M_\Delta = 10$ fixed)

Both restore unification at one loop [with however a too low $M_{\text{GUT}}$ in case (i): must rely on 2-loop RGES and GUT threshold effects to increase it]

SO(10) is broken down to the SM gauge group by a 54', two 45 with vevs aligned in the $T_{3R}$ and B-L directions, and the $16 \oplus \overline{16}$ which breaks the rank

the 10 and $16 \oplus \overline{16}$ contain both Higgs doublets and colour triplets. The doublet-triplet splitting is realized à la Dimopoulos-Wilczek using the 45_{B-L}

to suppress proton decay from coloured triplet exchange, one pair of Higgs doublets must have a mass $M_H \lesssim 10^{14}$ GeV
SO(10) gauge symmetry breaking

The superpotential

\[
\frac{1}{2} f_1 54' 45_1 45_1 + (\lambda_{12} S + f_{12} 54') 45_1 45_2 + \frac{1}{3} \lambda 54' 54' 54' + 16 (M_{16} + g 45_1) 16
\]

leads to the vacuum

\[
V_{B-L}^{(1)} = V_R^{(2)} = 0, \quad V_R^{(1)} = \frac{1}{2g} M_{16}, \quad V_{B-L}^{(2)} = -\frac{3\sqrt{3} f_1}{10\sqrt{2} f_{12} g} M_{16},
\]

\[
V_{54'}^2 = -\frac{3f_1}{8\lambda g^2} M_{16}^2, \quad S = -\frac{\sqrt{3} f_{12}}{2\sqrt{5} \lambda_{12}} V_{54'}, \quad V_{16} V_{16}^{16} = \frac{\sqrt{3} f_1}{8\sqrt{5} g^2} V_{54'} M_{16}
\]

SO(10) is broken in one step down to the SM gauge group if all dimensionless couplings are of order one.
Doublet-triplet splitting

Introduce and additional $10'$

$$W_{DT} = \frac{1}{2} M_{10'} 10' 10' + h 10' 45 2 10 + \overline{16}(M_{16} + g 45_1) 16 + \frac{1}{2} \eta \overline{16} 16 10$$

Doublet and triplet mass matrices:

$$M_D = \begin{pmatrix} 0 & 0 & -\eta V_{16}^T \\ 0 & M_{10'} & 0 \\ 0 & 0 & M_{16} \end{pmatrix} \quad M_T = \begin{pmatrix} 0 & \frac{h}{\sqrt{6}} V_{B-L} & -\eta V_{16} \\ -\frac{h}{\sqrt{6}} V_{B-L} & M_{10'} & 0 \\ 0 & 0 & M_{16} + 2g V_R \end{pmatrix}$$

Light Higgs doublets:

$$h_u = H_u^{10} \quad h_d = \cos \theta_H H_d^{10} + \sin \theta_H H_d^{16} \quad \tan \theta_H = \frac{\eta V_{16}}{M_{16}}$$

D=5 proton decay operator proportional to:

$$\left(M_T^{-1}\right)_{T10\overline{T16}} = \frac{3\eta V_{16} M_{10'}}{M_{16} (h V_{B-L})^2}$$

$$\Rightarrow \text{«conservative» upper bound: } M_{10'} \lesssim 10^{14} \text{ GeV}$$
Spectrum of heavy states [scenario (ii) with $M_\Delta = 10^{12}$ GeV, $\lambda_H = 0.045$, $V_1^{16} = M_{GUT}$, $\tan \theta_H = 1$, $\tan \beta = 10$]
Numerical results

- we assume universal soft terms at \( M_{GUT} \), with \( A_0 = 0 \) and \( \mu > 0 \)
- we require radiative electroweak symmetry breaking and impose the experimental limits on the Higgs and superpartner masses and on \( \text{BR} (b \rightarrow s\gamma), \text{BR} (B_{d,s}^0 \rightarrow \mu^+\mu^-), \Delta m_K, \Delta m_D, \Delta m_B \) and \( \Delta m_{B_s} \)
- we choose values of the light neutrino parameters favoured by leptogenesis: \( m_{\nu_1} = 0.005 \text{ eV}, \sin^2 \theta_{13} = 0.05, \rho = \pi/4, \sigma = \pi/2 \) \([\delta = 0]\)
- we consider scenario (ii) \([\text{scenario (i) would give similar results}]\)
  with \( V_{16}^{16} = M_{GUT} \) and \( \tan \theta_H = 1 \)
Susy parameters: \( m_0 = M_{1/2} = 700 \text{ GeV}, \ A_0 = 0, \ \tan \beta = 10, \ \mu > 0 \)

Strong dependence of \( \text{BR} (\mu \rightarrow e \gamma) \) on the seesaw parameters:

\[
\text{BR} (\mu \rightarrow e \gamma) \sim |(m_L^2)_{21}|^2 \sim |(f^\dagger f)_{21}|^2 \sim (M_\Delta/\lambda_H)^4
\]

Large values of the \( f_{ij} \)'s excluded \( \Rightarrow \) leptogenesis can work only in a small region of the seesaw parameter space (otherwise \( \varepsilon_\Delta \) too small)
From now on, choose a point in the region of the seesaw parameter space not excluded by $\mu \rightarrow e \gamma$ where leptogenesis can work:

$$M_\Delta = 10^{12} \text{ GeV}, \quad \lambda_H = 0.045$$

The ongoing experiment MEG (which will reach a sensitivity of $10^{-13}$) will probe most of the Susy parameter space for this point.
The region of the Susy parameter space that will be probed by MEG will also be accessible at the LHC.
Sleptons are heavy – the lightest neutralino is always the LSP.

\[ m_0 = M_{1/2} = 700 \text{ GeV}, \]
\[ A_0 = 0, \tan \beta = 10 \]
Correlations between $\mu \rightarrow e \gamma$ and other LFV processes

Susy parameters: $m_0 = M_{1/2} = 700$ GeV, $A_0 = 0$, $\tan \beta = 10$, $\mu > 0$
$\text{BR} (\tau \to \mu \gamma) \lesssim 2 \times 10^{-11}$: not competitive with $\mu \to e \gamma$ (out of reach of super B factories)

The correlation between $\mu \to e \gamma$ and $\tau \to \mu \gamma$ is characteristic of the supersymmetric type II seesaw:

$$\frac{\text{BR} (\tau \to \mu \gamma)}{\text{BR} (\mu \to e \gamma)} \approx 0.17 \left| \frac{(m^2_L)_{32}}{(m^2_L)_{21}} \right|^2 \approx 0.17 \left| \frac{(M^\dagger \nu M_\nu)_{32}}{(M^\dagger \nu M_\nu)_{21}} \right|^2 \approx 1.5$$

for $\theta_{13}$ close to its experimental upper limit

$\mu - e$ conversion looks more promising: the projects Mu2e at FNAL and PRISM/PRIME at J-PARC aim at $10^{-16}$ and $10^{-18}$ (the present upper limit is $4.3 \times 10^{-12}$) – would be a more powerful probe than MEG

Finally, $\text{BR} (\mu \to 3e) \lesssim 10^{-13}$ (the present upper limit is $1.0 \times 10^{-12}$)
Effect of relaxing the universality of soft scalar masses (keeping them flavour blind), for $M_{1/2} = 700 \text{ GeV}$, $A_0 = 0$, $\tan \beta = 10$

Most points remain within the reach of MEG, unless the lightest slepton is very heavy
The only hadronic observable that may receive a significant contribution (in the presence of a large phase, here $\arg \left( (m_{d,c}^2)_{12} \right) = 0.5$) is $\epsilon_K$

The supersymmetric contribution could easily reach the $10^{-4}$ level, enough to account for 10% - 20% of the observed value, $(2.229 \pm 0.012) \times 10^{-3}$ [the SM contribution is estimated to be $(1.78 \pm 0.25) \times 10^{-3}$ by Buras and Guadagnoli, arXiv:0901.2056]
Conclusions

• embedding the SM fermions in both 16 and 10 representations of SO(10) makes it possible to realize the type II seesaw mechanism and leads to a predictive scenario of leptogenesis

• the pattern of flavour violation in this scenario shows some difference with the standard type II seesaw due to the presence of heavy quark and lepton fields

• in the region of seesaw parameters where leptogenesis can work, definite predictions for LFV processes which can be tested by the ongoing MEG experiment (barring cancellations with other sources of LFV, e.g. from supersymmetry breaking)

• in the absence of a positive signal at MEG, the discovery of a relatively light superpartner spectrum at the LHC would strongly disfavour this scenario