Lepton Flavor Violation and Neutrino Physics

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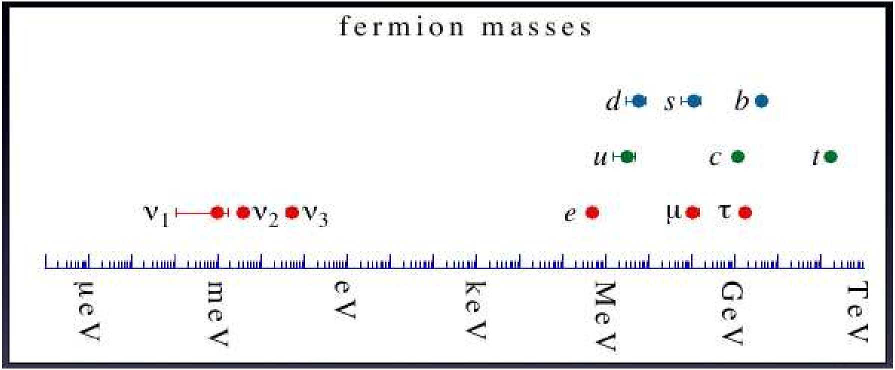
Open questions

1. **Which is the underlying mechanism regulating the EWSB?**
2. **Which is the connection between EWSB and flavor physics?**
3. **Are there new flavor symmetries beyind the puzzling fermion mass spectrum?**
4. **Are there new flavor violating interactions not governed by the SM Yukawas? That is, to which extent the MFV hypothesis is valid?**
5. **Do the new sources of CPV accounting for the BAU have an impact on flavor physics and/or EDMs?**
6. **Which is the role of flavor physics in the LHC era?**
7. **Do we expect to understand the (SM and NP) flavor puzzles through the interplay of flavor physics and the LHC?**
8. **......**

The fermion mass puzzle



$$|\mathbf{V_{CKM}}| \sim \begin{pmatrix} 1 & \lambda_{\mathbf{c}} & \lambda_{\mathbf{c}}^3 \\ \lambda_{\mathbf{c}} & 1 & \lambda_{\mathbf{c}}^2 \\ \lambda_{\mathbf{c}}^3 & \lambda_{\mathbf{c}}^2 & 1 \end{pmatrix}, \quad |\mathbf{V_{PMNS}}| \simeq \begin{pmatrix} 0.79-0.86 & 0.50-0.61 & 0.0-0.2 \\ 0.25-0.53 & 0.47-0.73 & 0.56-0.79 \\ 0.21-0.51 & 0.42-0.69 & 0.61-0.83 \end{pmatrix}_{\mathbf{3}\sigma}$$

Hierarchical **Anarchic / Tribimaximal**

The fermion mass puzzle

- **Quark/charged-lepton mass hierarchy**

$$\begin{aligned} Y_t &\sim 1, & Y_c \sim 10^{-2}, \quad Y_u \sim 10^{-5} \\ Y_b &\sim 10^{-2}, & Y_s \sim 10^{-3}, \quad Y_d \sim 10^{-4} \\ Y_\tau &\sim 10^{-2}, & Y_\mu \sim 10^{-3}, \quad Y_e \sim 10^{-6} \end{aligned}$$

- **Quark mixing angles hierarchy**

$$|V_{us}| \sim 0.2, \quad |V_{cb}| \sim 0.04, \quad |V_{ub}| \sim 0.004 \quad (\delta_{KM} \sim 1)$$

- **Neutrinos**

$$\begin{aligned} \Delta m^2_{sol} &= (7.9 \pm 0.3) \times 10^{-5}\mathrm{eV}^2, \quad |\Delta m^2_{atm}| = (2.6 \pm 0.2) \times 10^{-3}\mathrm{eV}^2, \\ \sin^2\theta_{sol} &= 0.31 \pm 0.02, \quad \sin^2\theta_{atm} = 0.47 \pm 0.07, \quad \sin^2\theta_{e3} = 0^{+0.08}_{-0.0}, \end{aligned}$$

- **Quark-Lepton complementarity: GUT + Flavor Symmetry?** [Raidal '04]

$$\theta_{sol} + \theta_c \approx \frac{\pi}{4}, \qquad \theta_{atm} + \theta_{23} \approx \frac{\pi}{4}$$

- **SM gauge couplings**

$$g_s \sim 1, \quad g \sim 0.6, \quad g^{'} \sim 0.3, \quad \lambda_{\mathrm{Higgs}} \sim 1$$

NP search strategies

- **High-energy frontier: A unique effort to determine the NP scale**

- **High-intensity frontier (flavor physics): A collective effort to determine the flavor structure of NP**

Where to look for New Physics at the low energy?

- **Processes very suppressed or even forbidden in the SM**
  - FCNC processes ($\mu \to e\gamma$, $\tau \to \mu\gamma$, $B^0_{s,d} \to \mu^+\mu^-$, $K \to \pi\nu\bar{\nu}$)
  - CPV effects in the electron/neutron EDMs, $d_{e,n}$...
  - FCNC & CPV in $B_{s,d}$ decay/mixing & D mixing amplitudes

- **Processes predicted with high precision in the SM**
  - EWPO as $\Delta\rho$, $(g-2)_\mu$....
  - LU in $R_M^{e/\mu} = \Gamma(K(\pi) \to e\nu)/\Gamma(K(\pi) \to \mu\nu)$

Experimental status

Brief status of Lepton Flavor Violation searches

- tau LFV
  - past: CLEO explored up to BRs $\sim 10^{-6}$
  - **present: B-factories are completing exploration up to BRs $\sim 10^{-8}$**
  - future: Super Flavor Factories can explore up to BRs $\sim 10^{-10}$
  - **$\tau \to \mu\gamma$ is the most sensitive channel for most mainstream NP models**
- muon LFV
  - past: LAMPF, MEGA, BF($\mu \to e\gamma$) $< 1.2 \cdot 10^{-11}$ at 90% CL
  - past: SINDRUM II, BF($\mu \to e$ in nucleon field) $< 7 \cdot 10^{-13}$ at 90% CL
  - **present: MEG, BF($\mu \to e\gamma$) $< 1.5 \cdot 10^{-11}$ at 90% CL, (sensitivity $6 \cdot 10^{-12}$)**
  - future: MEG will soon reach sensitivity $\sim 10^{-13}$
  - future: Mu2E and COMET/PRISM can much increase reach on BF($\mu \to e$ in nucleon field)

Process	Expected 90% CL upper limit	3σ evidence reach
BF($\tau \to \mu\gamma$)	$2.4 \cdot 10^{-9}$	$5.4 \cdot 10^{-9}$
BF($\tau \to e\gamma$)	$3.0 \cdot 10^{-9}$	$6.8 \cdot 10^{-9}$
BF($\tau \to \ell\ell\ell$)	$2.3\text{–}8.2 \cdot 10^{-10}$	$1.2\text{–}4.0 \cdot 10^{-9}$

[Lusiani @ HQL10]

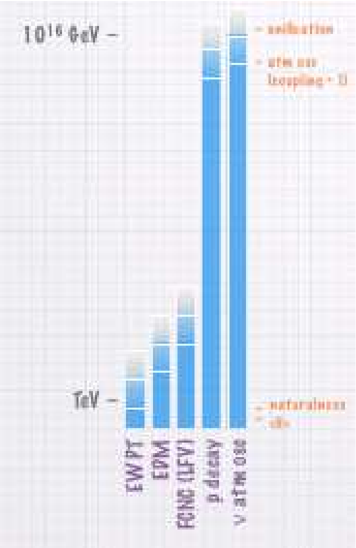
The NP “scale”

- **Gravity** $\Longrightarrow$ $\Lambda_{\text{Planck}} \sim 10^{18-19}$ GeV
- **Neutrino masses** $\Longrightarrow$ $\Lambda_{\text{see-saw}} \lesssim 10^{15}$ GeV
- **Hierarchy problem**: $\Longrightarrow$ $\Lambda_{\text{NP}} \lesssim$ TeV
- **Dark Matter** $\Longrightarrow$ $\Lambda_{\text{NP}} \lesssim$ TeV
- **BAU**: evidence of CPV beyond SM
  - Electroweak Baryogenesis $\Longrightarrow$ $\Lambda_{\text{NP}} \lesssim$ TeV
  - Leptogenesis $\Longrightarrow$ $\Lambda_{\text{see-saw}} \lesssim 10^{15}$ GeV

SM = effective theory at the EW scale

$$\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{SM}} + \sum_{d\geq 5} \frac{c_{ij}^{(d)}}{\Lambda_{NP}^{d-4}}\, O_{ij}^{(d)}$$

- $\mathcal{L}_{\text{eff}}^{d=5} = \frac{y_\nu^{ij}}{\Lambda_{\text{see-saw}}} L_i L_j \phi\phi,$
- $\mathcal{L}_{\text{eff}}^{d=6}$ generates FCNC operators



$$\mathbf{BR}(\ell_i \to \ell_j\gamma) \sim \frac{1}{\Lambda_{NP}^4}$$

LFV frameworks

- **Neutrino Oscillation** $\Rightarrow m_{\nu_i} \neq m_{\nu_j} \Rightarrow$ **LFV**

- **see-saw**: $m_\nu = \frac{(m_\nu^D)^2}{M_R} \sim eV$, $M_R \sim 10^{14-16} \Rightarrow m_\nu^D \sim m_{top}$

- LFV transitions like $\mu \to e\gamma$ @ 1 loop with exchange of
  - W and ν in the SM framework (GIM) with $\Lambda_{NP} \equiv M_R$

$$Br(\mu \to e\gamma) \sim \frac{m_\nu^{D\,4}}{M_R^4} \leq 10^{-50}$$

  - $\tilde{W}$ and $\tilde{\nu}$ in the MSSM framework (SUPER-GIM) with $\Lambda_{NP} \equiv \tilde{m}$

$$Br(\mu \to e\gamma) \sim \frac{m_\nu^{D\,4}}{\tilde{m}^4} \leq 10^{-11}$$

$$\Downarrow$$

- LFV signals are undetectable (detectable) in the SM (MSSM)

Flavour universal SUSY breaking and yet large LFV from SUSY see-saw

- SUSY see-saw superpotential (MSSM + RN)

$$W = h^e L e^c H_1 + h^\nu L \nu^c H_2 + M_R \nu^c \nu^c + \mu H_1 H_2,$$

$$\mathcal{M}_\nu = -h^\nu M_R^{-1} h^{\nu\ T} v_2^2,$$

$$M_{\tilde{\ell}}^2 = \begin{pmatrix} m_L^2(1+\delta_{LL}^{ij}) & (A-\mu t_\beta)m_\ell + m_L m_R \delta_{LR}^{ij} \\ (A-\mu t_\beta)m_\ell + m_L m_R {\delta_{LR}^{ij}}^\dagger & m_R^2(1+\delta_{RR}^{ij}) \end{pmatrix}$$

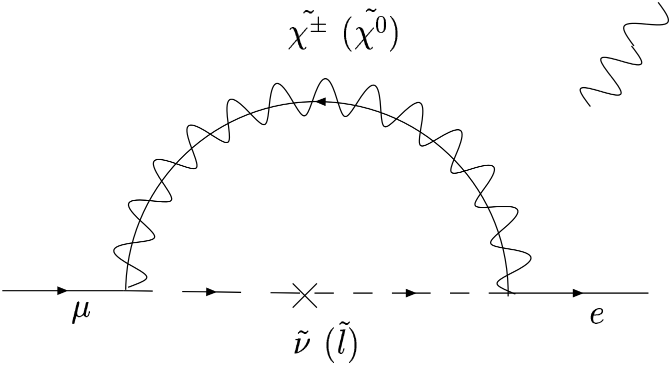
- If $h^e = h^e_{ij}\delta_{ij}$ and $M_R = (M_R)_{ij}\delta_{ij} \Rightarrow h^\nu \neq h^\nu_{ij}\delta_{ij}$ in general.

$$\delta_{LL}^{ij} \approx -\frac{3}{8\pi^2}(h^\nu h^{\nu\dagger})_{ij} \ln\frac{M_X}{M_R},$$

[Borzumati & Masiero, '86]

LFV interactions – leptons/sleptons/gauginos

$$\mathcal{L} = \bar{\ell}_i \left(C^R_{ijA} P_R + C^L_{ijA} P_L \right) \tilde{\chi}^-_A \tilde{\nu}_j + \bar{\ell}_i \left(N^R_{ijA} P_R + N^L_{ijA} P_L \right) \tilde{\chi}^0_A \tilde{\ell}_j$$



$$\frac{BR(\ell_i \to \ell_j \gamma)}{BR(\ell_i \to \ell_j \nu_i \bar{\nu}_j)} \sim \left(\frac{m^4_W}{m^4_{SUSY}} \right) \left(\delta^{21}_{LL} \right)^2 t^2_\beta \qquad \delta_{LL} \sim h^\nu h^{\nu\dagger}$$

LFV in SUSY

h^ν is unknown $\Rightarrow$ No model independent predictions for LFV

$$h^\nu = U^\star_{\mathrm{MNS}}\, \mathcal{D}_{\sqrt{\mathcal{M}_\nu}}\, R^T\, \mathcal{D}_{\sqrt{M_R}}\, \frac{1}{v_2},$$

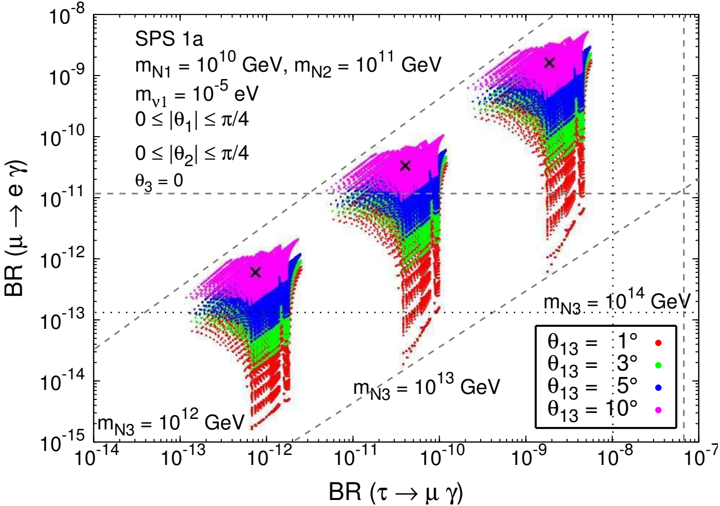
$R^\dagger R = 1 \Rightarrow$ **three angles** and **three phases**

- **ν_L & ν_R hierarchical (and R real)**

$$\frac{B(\mu \to e\gamma)}{B(\tau \to \mu\gamma)} \sim \frac{|U_{e3}|^2}{B(\tau \to \mu\nu_\tau\bar{\nu}_\mu)}$$

- **ν_L hierarchical and ν_R degenerate (and R real)**

$$\frac{B(\mu \to e\gamma)}{B(\tau \to \mu\gamma)} \sim \frac{|s_{12}c_{12}\,(m_{sol}/m_{atm}) + U_{e3}|^2}{B(\tau \to \mu\nu_\tau\bar{\nu}_\mu)}$$



[Herrero et al., '06]

RG induced LFV interactions in SUSY GUTs

- **SUSY SU(5)** [Barbieri & Hall, '95]

$$(\delta^{\tilde{q}}_{LL})_{ij} \sim h^u h^{u\dagger}{}_{ij} \sim h_t^2 V^{ik}_{CKM} V^{kj*}_{CKM} \rightarrow (\delta^{\tilde{\ell}}_{RR})_{ij} \simeq (\delta^{\tilde{q}}_{LL})_{ij}$$

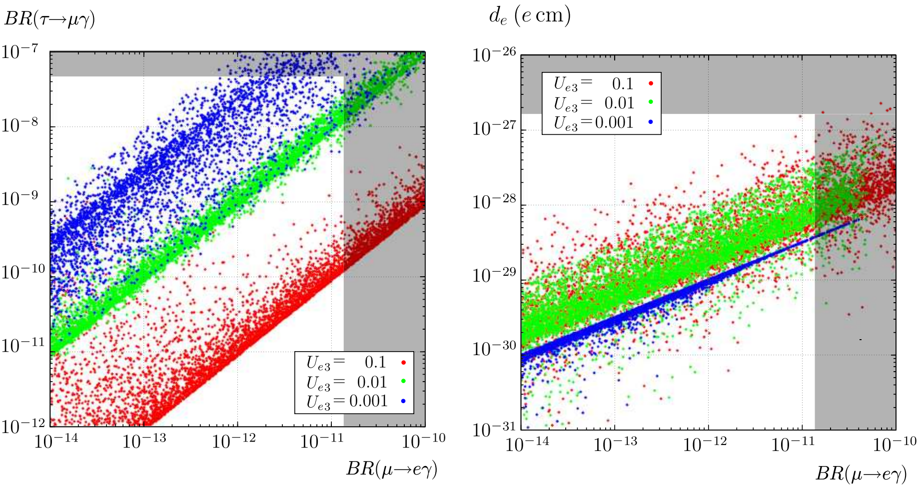
- **SUSY SU(5)+RN** [Yanagida et al., '95]

$$(\delta^{\tilde{\ell}}_{LL})_{ij} \sim (h^\nu h^{\nu\dagger})_{ij} \qquad \& \qquad (\delta^{\tilde{\ell}}_{RR})_{ij} \sim (h^u h^{u\dagger})_{ij}$$

- **SUSY SU(5)+RN** [Moroi, '00] **&** **SO(10)** [Chang, Masiero & Murayama, '02]

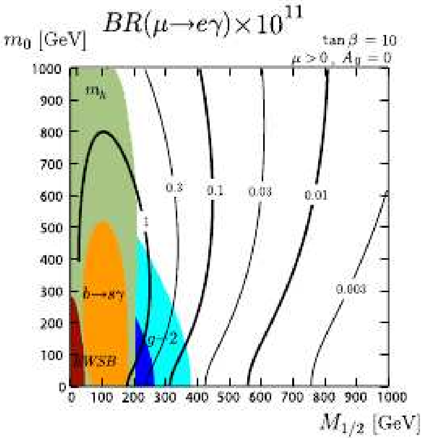
$$\sin\theta_{\mu\tau} \sim \frac{\sqrt{2}}{2} \Rightarrow (\delta^{\tilde{\ell}}_{LL})_{23} \sim 1 \Rightarrow (\delta^{\tilde{q}}_{RR})_{23} \sim 1$$

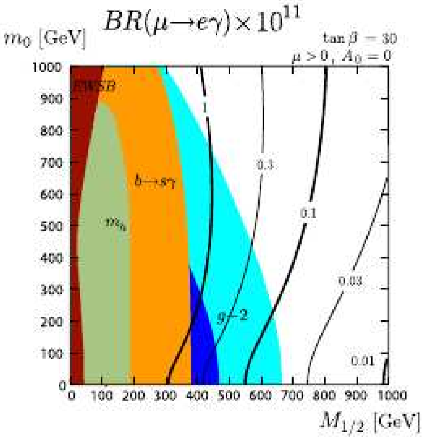
$\mu \to e\gamma$ and $\tau \to \mu\gamma$ in SUSY SU(5)+RN



[Hisano, Nagai, Paradisi & Shimizu, '09]

$\mathrm{BR}(\mu \to e\gamma)$ in $SU(5)_{RN}$ and the LHC reach

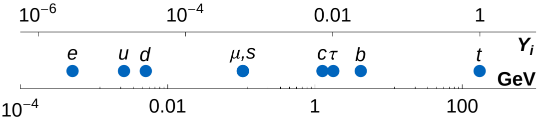




hierarchical ν_L **and** N_R**,** $U_{e3} = 0.1$**,** $M_{N_3} = 10^{-13}\,\mathrm{GeV}$

[Hisano, Nagai, Paradisi & Shimizu, '09]

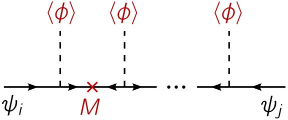
SM vs. NP flavor puzzle



$V_{\mathrm{CKM}} \sim$ 

Froggat-Nielsen '79: Hierarchies from SSB of a Flavour Symmetry

$$\epsilon = \frac{\langle\phi\rangle}{M} \ll 1 \Rightarrow Y_{ij} \propto \epsilon^{(a_i+b_j)}$$

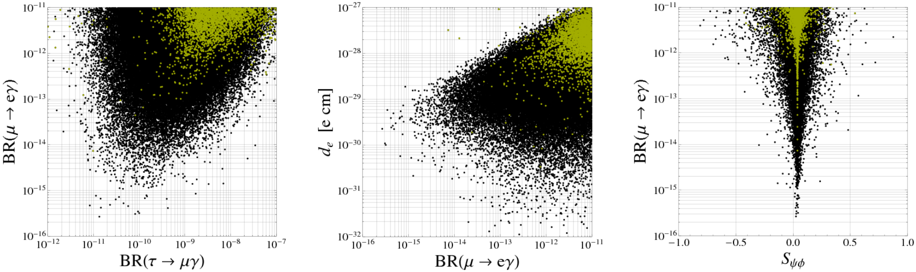


Non-abelian $SU(3)$ SUSY flavour model [Ross, Velasco-S., Vives]

$$\delta_d^{LL} \sim \begin{pmatrix} \cdot & \lambda^5 & \lambda^3 \\ \lambda^5 & \cdot & \lambda^2 \\ \lambda^3 & \lambda & \cdot \end{pmatrix} \qquad \delta_d^{RR} \sim \begin{pmatrix} \cdot & \lambda^3 & \lambda^2 \\ \lambda^3 & \cdot & \lambda \\ \lambda^2 & \lambda & \cdot \end{pmatrix}$$

$$\delta_\ell^{LL} \sim \begin{pmatrix} \cdot & \frac{\lambda^5}{3} & \frac{\lambda^3}{3} \\ \frac{\lambda^5}{3} & \cdot & \lambda^2 \\ \frac{\lambda^3}{3} & \lambda & \cdot \end{pmatrix} \qquad \delta_\ell^{RR} \sim \begin{pmatrix} \cdot & \frac{\lambda^3}{3} & \frac{\lambda^2}{3} \\ \frac{\lambda^3}{3} & \cdot & \lambda \\ \frac{\lambda^2}{3} & \lambda & \cdot \end{pmatrix}$$

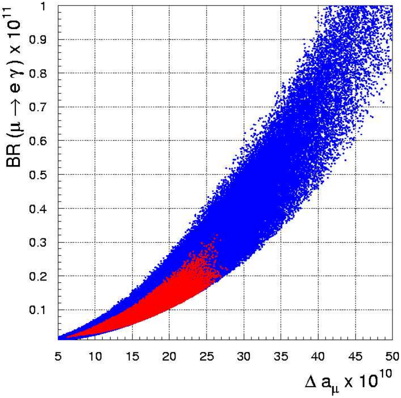
Phenomenology of a SUSY SU(3) flavor models

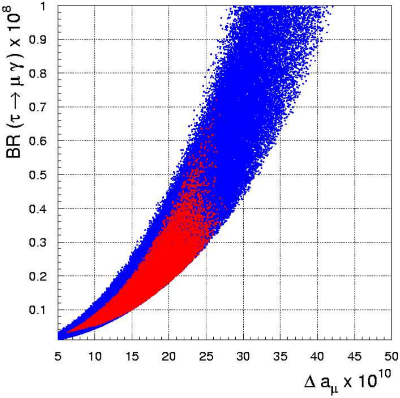


- Yellow points satisfy $\Delta a_\mu > 10^{-9}$
- Scan ranges: $m_0 < 2$ TeV, $M_{1/2} < 1$ TeV, $|A_0| < 3m_0$, $5 < \tan\beta < 55$

[Altmannshofer, Buras, Gori, Paradisi and Straub, '09]

$(g-2)_\mu$ vs $\ell_i \to \ell_j \gamma$





$|\delta_{LL}^{12}| = 10^{-4}$ and $|\delta_{LL}^{23}| = 10^{-2}$,

[Isidori, Mescia, Paradisi & Temes, 07]

$$BR(\ell_i \to \ell_j \gamma) \approx \left[\frac{\Delta a_\mu}{20 \times 10^{-10}}\right]^2 \times \left\{ \begin{array}{lll} 1 \times 10^{-4} & \left|\delta_{LL}^{12}\right|^2 & [\mu \to e] \\ 2 \times 10^{-5} & \left|\delta_{LL}^{23}\right|^2 & [\tau \to \mu] \end{array} \right\}$$

The P-odd asymmetry in $\mu^+ \to e^+\gamma$ [Okada et al., '96]

- **After $\mu^+ \to e^+\gamma$ will be (hopefully!) observed...**

$$\frac{\mathrm{BR}(\ell_i \to \ell_j\gamma)}{\mathrm{BR}(\ell_i \to \ell_j\nu_i\bar{\nu}_j)} = \frac{48\pi^3\alpha_{em}}{G_F^2}\left(|A_L^{\ell_i\ell_j}|^2 + |A_R^{\ell_i\ell_j}|^2\right)$$

$$A(\mu^+ \to e^+\gamma) = \frac{|A_L|^2 - |A_R|^2}{|A_L|^2 + |A_R|^2}$$

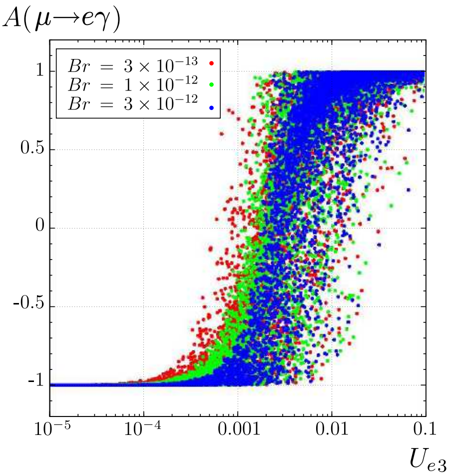
- **SUSY see-saw**

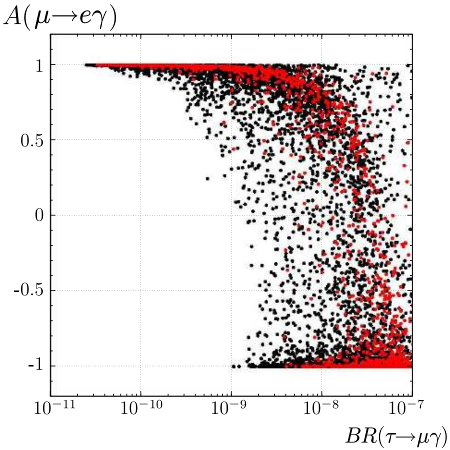
$$A_L^{\mu e} = \frac{\alpha_2}{4\pi}\frac{t_\beta}{\tilde{m}^2}\frac{\delta^L_{\mu e}}{15} \qquad A_R^{\mu e} \simeq \frac{m_e}{m_\mu}A_L^{\mu e}$$

- **SUSY SU(5)+RN**

$$A_L^{\mu e} = \frac{\alpha_2}{4\pi}\frac{t_\beta}{\tilde{m}^2}\frac{\delta^L_{\mu e}}{15} \qquad A_R^{\mu e} = -\frac{\alpha_Y}{4\pi}\frac{t_\beta}{\tilde{m}^2}\frac{m_\tau}{m_\mu}\frac{\delta^L_{\mu\tau}\delta^R_{\tau e}}{30}$$

$A(\mu \to e\gamma)$ in SUSY SU(5)+RN





[Hisano, Nagai, Paradisi & Shimizu, '09]

Pattern of LFV in NP models

- **Ratios like $Br(\mu \to e\gamma)/Br(\tau \to \mu\gamma)$ probe the NP flavor structure**
- **Ratios like $Br(\mu \to e\gamma)/Br(\mu \to eee)$ probe the NP operator at work**

ratio	LHT	MSSM	SM4
$\frac{Br(\mu\to eee)}{Br(\mu\to e\gamma)}$	$0.02\ldots1$	$\sim 2\cdot10^{-3}$	$0.06\ldots2.2$
$\frac{Br(\tau\to eee)}{Br(\tau\to e\gamma)}$	$0.04\ldots0.4$	$\sim 1\cdot10^{-2}$	$0.07\ldots2.2$
$\frac{Br(\tau\to\mu\mu\mu)}{Br(\tau\to\mu\gamma)}$	$0.04\ldots0.4$	$\sim 2\cdot10^{-3}$	$0.06\ldots2.2$
$\frac{Br(\tau\to e\mu\mu)}{Br(\tau\to e\gamma)}$	$0.04\ldots0.3$	$\sim 2\cdot10^{-3}$	$0.03\ldots1.3$
$\frac{Br(\tau\to\mu ee)}{Br(\tau\to\mu\gamma)}$	$0.04\ldots0.3$	$\sim 1\cdot10^{-2}$	$0.04\ldots1.4$
$\frac{Br(\tau\to eee)}{Br(\tau\to e\mu\mu)}$	$0.8\ldots2$	~ 5	$1.5\ldots2.3$
$\frac{Br(\tau\to\mu\mu\mu)}{Br(\tau\to\mu ee)}$	$0.7\ldots1.6$	~ 0.2	$1.4\ldots1.7$
$\frac{\mathrm{R}(\mu\mathrm{Ti}\to e\mathrm{Ti})}{Br(\mu\to e\gamma)}$	$10^{-3}\ldots10^{2}$	$\sim 5\cdot10^{-3}$	$10^{-12}\ldots26$

[Buras et al., '07, '10]

"DNA-Flavour Test"

SUSY model	GMSSM	AC	RVV2	AKM	δLL	FBMSSM	
$S_{\phi K_S}$	★★★	★★★	●●	■	★★★	★★★	SuperB
$A_{\rm CP}(B \to X_s\gamma)$	★★★	■	■	■	★★★	★★★	
$B \to K^{(*)}\nu\bar{\nu}$	●●	■	■	■	■	■	
$\tau \to \mu\gamma$	★★★	★★★	★★★	■	★★★	★★★	
$D^0 - \bar{D}^0$	★★★	★★★	■	■	■	■	SuperB
$A_{7,8}(B \to K^*\mu^+\mu^-)$	★★★	■	■	■	★★★	★★★	vs.
$A_9(B \to K^*\mu^+\mu^-)$	★★★	■	■	■	■	■	LHCb
$S_{\psi\phi}$	★★★	★★★	★★★	★★★	■	■	LHCb
$B_s \to \mu^+\mu^-$	★★★	★★★	★★★	★★★	★★★	★★★	
ϵ_K	★★★	■	★★★	★★★	■	■	
$K^+ \to \pi^+\nu\bar{\nu}$	★★★	■	■	■	■	■	
$K_L \to \pi^0\nu\bar{\nu}$	★★★	■	■	■	■	■	
$\mu \to e\gamma$	★★★	★★★	★★★	★★★	★★★	★★★	
$\mu + N \to e + N$	★★★	★★★	★★★	★★★	★★★	★★★	
d_n	★★★	★★★	★★★	★★★	●●	★★★	
d_e	★★★	★★★	★★★	●●	■	★★★	
$(g-2)_\mu$	★★★	★★★	★★★	●●	★★★	★★★	

[Altmannshofer et al., '09]

$\mu - e$ universality in $K \to l\nu$

$$R_K = \frac{\Gamma(K \to e\nu_e) + \Gamma(K \to e\nu_\mu) + \Gamma(K \to e\nu_\tau)}{\Gamma(K \to \mu\nu_\mu) + \Gamma(K \to \mu\nu_e) + \Gamma(K \to \mu\nu_\tau)}$$

- Violations of **LU** in **CCI** can be classified as $(R_K/R_K^{SM} = 1 + \Delta r_{K\,NP}^{e-\mu})$
  - i) **Corrections** to $(V-A)\times(V-A)$ interaction through $W\ell\nu_\ell$ vertex correction induced by a loop of NP particles

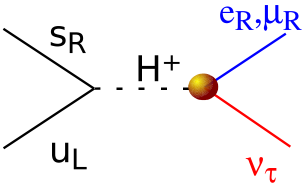
$$\Delta r_{SUSY}^{e-\mu} \sim \frac{\alpha_2}{4\pi}\left(\frac{\tilde{m}_\mu^2 - \tilde{m}_e^2}{\tilde{m}_\mu^2 + \tilde{m}_e^2}\right)\frac{m_W^2}{M_{SUSY}^2} \leq 10^{-4}$$

  - ii) **New Lorentz Structures**, i.e. **scalar CCI** with $H\ell\nu \sim m_\ell \tan\beta$.

	$(R_K^{e/\mu})_{exp.}$ $[10^{-5}]$
PDG 2006	2.45 ± 0.11
KLOE '09.	2.477 ± 0.01
NA62 '11.	2.487 ± 0.013
SM prediction (Cirigliano & Rossel '07)	2.477 ± 0.001

R_K^{LFV} in SUSY

$$R_K^{LFV} = \frac{\sum_i K \to e\nu_i}{\sum_i K \to \mu\nu_i} \simeq \frac{\Gamma_{SM}(K \to e\nu_e) + \Gamma(K \to e\nu_\tau)}{\Gamma_{SM}(K \to \mu\nu_\mu)} \;, \quad i = e, \mu, \tau$$



$$eH^\pm \nu_\tau \to \frac{g_2}{\sqrt{2}} \frac{m_\tau}{M_W} \Delta_R^{31} \tan^2\beta$$

$$\Delta_R^{31} \sim \frac{\alpha_2}{4\pi} \, \delta_{RR}^{31}$$

$$\Delta_R^{31} \sim 5 \cdot 10^{-4} \;\; t_\beta = 40 \;\; M_{H^\pm} = 500\,\mathrm{GeV}$$

$$\Downarrow$$

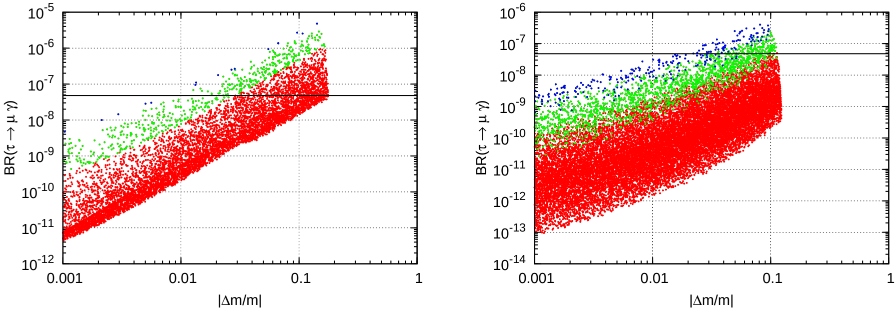
$$\Delta r_{K\,SUSY}^{e-\mu} \simeq \left(\frac{m_K^4}{M_{H^\pm}^4}\right)\left(\frac{m_\tau^2}{m_e^2}\right) |\Delta_R^{31}|^2 \tan^6\beta \approx 10^{-2}$$

$$\Delta r_{K\,SUSY}^{e-\mu} \approx 10^{-2} \quad \Longrightarrow \quad Br^{th.(exp.)}(\tau \to eX) \leq 10^{-10(-7)}$$

[Masiero, Paradisi and Petronzio, '05]

Slepton mass-splittings vs. LFV @ LHC

[Buras, Calibbi, Paradisi, '09]



$$\left|\frac{\Delta m_{\tilde{\ell}}}{m_{\tilde{\ell}}}\right| = \left|\frac{m_{\tilde{e}} - m_{\tilde{\mu}}}{m_{\tilde{\ell}}}\right| \simeq \frac{|\delta_{32}|}{2}$$

- For all points $\tilde{\chi}_2^0 \to \ell^\pm \tilde{\ell}^\mp \to \tilde{\chi}_1^0 \ell^\pm \ell^\mp$ ($\ell = e, \mu$) with $m_{\tilde{\ell}} < m_{\tilde{\chi}_2^0}$ → the di-lepton invariant mass spectrum has a prominent kinematic edge that may be measured up to 0.1% precision.
- Left, right: $\tan\beta = 10$, $m_0, M_{1/2} < 1$ TeV, $A_0 = 0$, $|\delta^{32}_{\rm LL,RR}| > 10^{-3}$.
- green (blue) points satisfy $\Delta a_\mu = \frac{(g-2)_\mu}{2} > 1(2) \times 10^{-9}$

Conclusions

The origin of flavour is still, to a large extent, a mystery. The most important open questions can be summarized as follow:

- **Which is the organizing principle behind the observed pattern of fermion masses and mixing angles?**

- **Are there extra sources of flavour symmetry breaking beside the SM Yukawa couplings which are relevant at the TeV scale?**

Evidence for LFV in charged leptons could tell us a lot...