LFV in B decays

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☞ *Main line of argument based on Glashow, DG, Lane, PRL 2015*

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vs.

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❶ + ❷ + ❸ $\Rightarrow$ *There seems to be BSM LFNU and the effect is in μμ, not ee*

Motivation 2

Actually, after some effective-theory insights, two further pieces of info support the above picture

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- *Yet:*
  - ***Q1:*** *Can we (easily) make sense of* ❶ to ❺ ?
  - ***Q2:*** *What are the most immediate signatures to expect ?*

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- *Rotating q and ℓ to the mass eigenbasis generates LFV interactions.*

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So, BSM LFNU $\Rightarrow$ BSM LFV (i.e. not suppressed by m_ν)

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- *"Generally small" means:*

  Barring MFV models where sizable LFV and small LH ν masses can be engineered to be so by tuning a dimensionful parameter to be small. (Back to fine tuning.)

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Plausible mechanism?

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We assume the above V – A structure to hold also beyond the SM, namely

$$C_9^{(\ell)} \approx -C_{10}^{(\ell)} \qquad \textit{with} \qquad C_{9,10}^{(\ell)} = C_{9,10}^{\mathrm{SM}} + C_{9,10}^{(\ell),\mathrm{NP}}$$

Such an hypothesis provides a successful fit to the discussed data.
See Altmannshofer-Straub, EPJC 2015.

cf. also Hiller, Schmaltz; Ghosh, Nardecchia, Renner; Hurth, Mahmoudi, Neshatpour

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  - *This rotation induces* *LFNU and LFV* *effects*

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$$H_{\mathrm{SM+NP}}(\bar{b} \to \bar{s}\mu\mu) = \boxed{-\frac{4G_F}{\sqrt{2}} V_{tb}^* V_{ts} \frac{\alpha_{\mathrm{em}}}{4\pi}} \left[\bar{b}_L \gamma^\lambda s_L \cdot \left(C_9^{(\mu)} \bar{\mu}\gamma_\lambda \mu + C_{10}^{(\mu)} \bar{\mu}\gamma_\lambda \gamma_5 \mu\right)\right]$$

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$$= \quad \beta_{\mathrm{SM}}$$

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Another good reason to pursue accuracy in the $B_s \to \mu\mu$ measurement

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The current BR(B+ → K+ μe) limit yields the weak bound

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A reliable prediction of the BR requires some more work:

- *phase-space factors are substantially different than in the μμ and ee cases (but can easily be accounted for)*

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Note, instead, that the "K-physics analogue" of R_K:

$$\frac{BR(K \to \pi\mu\mu)}{BR(K \to \pi e e)}$$

less interesting as it is long-distance dominated [see D'Ambrosio et al., 1998]

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More quantitative LFV predictions

LFV predictions in one of the two scenarios of [DG, Lane]

	$B^+ \to K^+ \mu^\pm \tau^\mp$	$B^+ \to K^+ e^\pm \tau^\mp$	$B^+ \to K^+ e^\pm \mu^\mp$
	1.14×10^{-8}	3.84×10^{-10}	0.52×10^{-9}
Exp:	$< 4.8 \times 10^{-5}$	$< 3.0 \times 10^{-5}$	$< 9.1 \times 10^{-8}$

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	$B_s \to \mu^\pm \tau^\mp$	$B_s \to e^\pm \tau^\mp$	$B_s \to e^\pm \mu^\mp$
	1.37×10^{-8}	4.57×10^{-10}	1.73×10^{-12}
Exp:	—	—	$< 1.1 \times 10^{-8}$

All predictions are phase-space corrected.

More signatures

For a recent discussion:
Alonso, Grinstein, Martin-Camalich,
PRL 14

- *Being defined above the EWSB scale, our assumed operator* $G\,\bar{b}'_L \gamma^\lambda b'_L\, \bar{\tau}'_L \gamma_\lambda \tau'_L$ *must actually be made invariant under* $SU(3)_c \times SU(2)_L \times U(1)_Y$

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$$\bar{b}'_L \gamma^\lambda b'_L \, \bar{\tau}'_L \gamma_\lambda \tau'_L \xrightarrow[\text{inv.}]{SU(2)_L} \begin{cases} \bar{Q}'_L \gamma^\lambda Q'_L \, \bar{L}'_L \gamma_\lambda L'_L & \textbf{[neutral-current int's only]} \\ \bar{Q}'^i_L \gamma^\lambda Q'^j_L \, \bar{L}'^j_L \gamma_\lambda L'^i_L & \textbf{[also charged-current int's]} \end{cases}$$

- *Thus, the generated structures are all of:*

$$t' t' \nu'_\tau \nu'_\tau \,, \qquad t' t' \tau' \tau' \,, \qquad b' b' \nu'_\tau \nu'_\tau \,, \qquad b' b' \tau' \tau' \,, \qquad \boxed{t' b' \tau' \nu'_\tau},$$

More signatures

For a recent discussion:
Alonso, Grinstein, Martin-Camalich, PRL 14

- *Being defined above the EWSB scale, our assumed operator* $G\, \bar{b}'_L \gamma^\lambda b'_L\, \bar{\tau}'_L \gamma_\lambda \tau'_L$ *must actually be made invariant under* $SU(3)_c \times SU(2)_L \times U(1)_Y$

See:
Bhattacharya, Datta, London, Shivashankara, PLB 15

$$\bar{b}'_L \gamma^\lambda b'_L\, \bar{\tau}'_L \gamma_\lambda \tau'_L \quad \xrightarrow[\text{inv.}]{SU(2)_L} \quad \begin{cases} \bar{Q}'_L \gamma^\lambda Q'_L\, \bar{L}'_L \gamma_\lambda L'_L & \text{[neutral-current int's only]} \\ \bar{Q}'^i_L \gamma^\lambda Q'^j_L\, \bar{L}'^j_L \gamma_\lambda L'^i_L & \text{[also charged-current int's]} \end{cases}$$

- *Thus, the generated structures are all of:*

$$t' t' \nu'_\tau \nu'_\tau\,, \qquad t' t' \tau' \tau'\,, \qquad b' b' \nu'_\tau \nu'_\tau\,, \qquad b' b' \tau' \tau'\,, \qquad \boxed{t' b' \tau' \nu'_\tau},$$

- *After rotation to the mass basis (unprimed), the last structure contributes to* $\Gamma(b \to c\, \tau\, \bar{\nu}_i)$

Can explain BaBar deviations on $R(D^{(*)}) = \dfrac{BR(\bar{B} \to D^{(*)+} \tau^- \bar{\nu}_\tau)}{BR(\bar{B} \to D^{(*)+} \ell^- \bar{\nu}_\ell)}$
(D channel confirmed by LHCb)*