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Phenomenological consequences of radiative flavor-violation in the MSSM

The model

The light fermion masses of the first two generations and the smallness of the off-diagonal CKM elements suggests the idea that they might be due to radiative corrections. However, the top and the tau Yukawa couplings are too big to be generated radiatively and the successful bottom-tau unification suggests to keep all third generation fermion Yukawa couplings. Thus we impose a $SU(2)^5$ flavor-symmetry on the MSSM superpotential and the bilinear SUSY breaking terms:

$$Y^q = \frac{1}{v_q}\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & m_{q_3} \end{pmatrix}, \quad Y^\ell = \frac{1}{v_d}\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & m_{\ell_3} \end{pmatrix}, \quad V_{CKM}^{(0)} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

All other elements are generated radiatively using the trilinear A-terms!

In this way we can explain the hierarchy of the fermion masses by a loop-suppression. For the first two generations no direction in flavor-space is singled out and the effective quark mass matrices are diagonal in the same basis as the A-terms. Therefore, regarding only the first two generations, the squark mass matrices are diagonal in the super-CKM basis and no direct constraints from Kaon or D mixing arise. For the third generation the quark-field rotations are fixed by the tree-level Yukawa couplings and the imposed flavor-symmetries. Thus the A-terms generate the off-diagonal CKM elements by a misalignment with the Yukawa couplings. This means that they are also non-minimal sources of flavor-violation. We can generate the CKM matrix either in the up or in the down sector (in principle also a intermediate scenario is possible)

CKM generation in the down-sector

The requirement of CKM generation in the down-sector means that we demand:

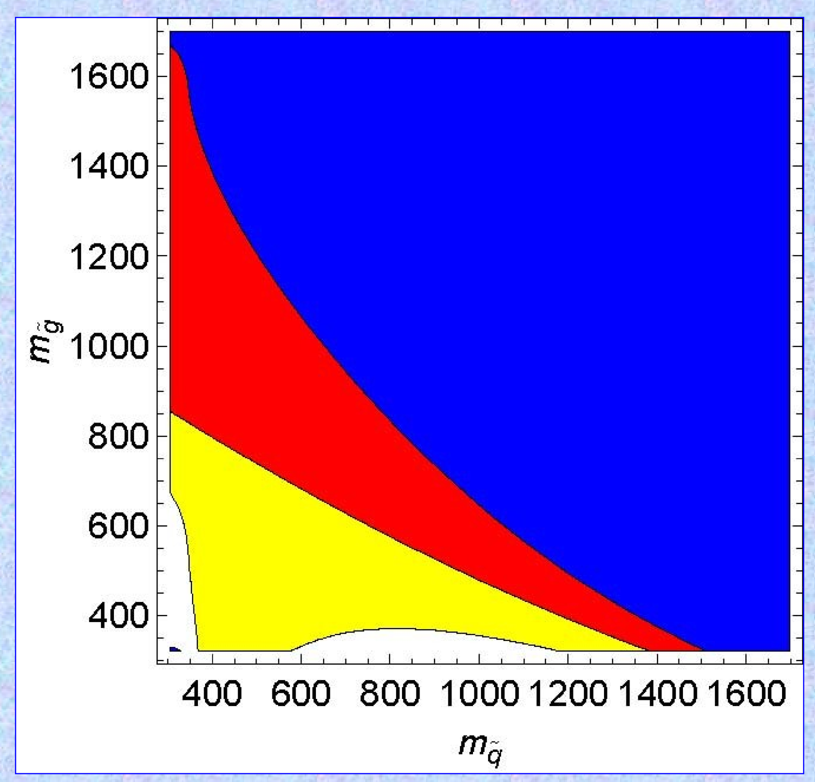
$$\Sigma_{13}^{d\,LR} \overset{!}{=} m_b V_{ub}, \quad \Sigma_{23}^{d\,LR} \overset{!}{=} m_b V_{cb}$$

In this case the most severe constraints from b→sγ which receives constructive contributions from squark-gluino diagrams.

b→sγ

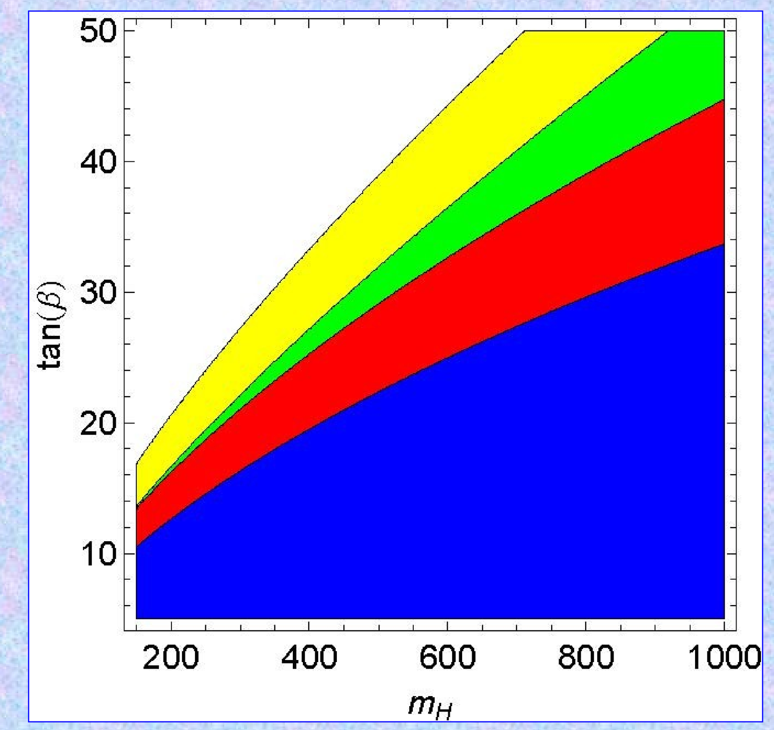
Allowed regions from b→sγ for different values of μ tan(β). We demand that the gluino contribution should not exceed the SM one.

- Blue: $\mu \tan(\beta) = -30\,TeV$
- Yellow: $\mu \tan(\beta) = 30\,TeV$
- Red: $\mu \tan(\beta) = 0\,TeV$



Non-decoupling effects

In the case of CKM generation in the down-sector the flavor-changing A-terms also induce flavour-changing neutral Higgs vertices which contribute to B_s→μμ and B_d→μμ if μ is not equal to zero. Since the relative effect, compared to the SM contribution is the same the constraints from B_s→μμ are more stringent.



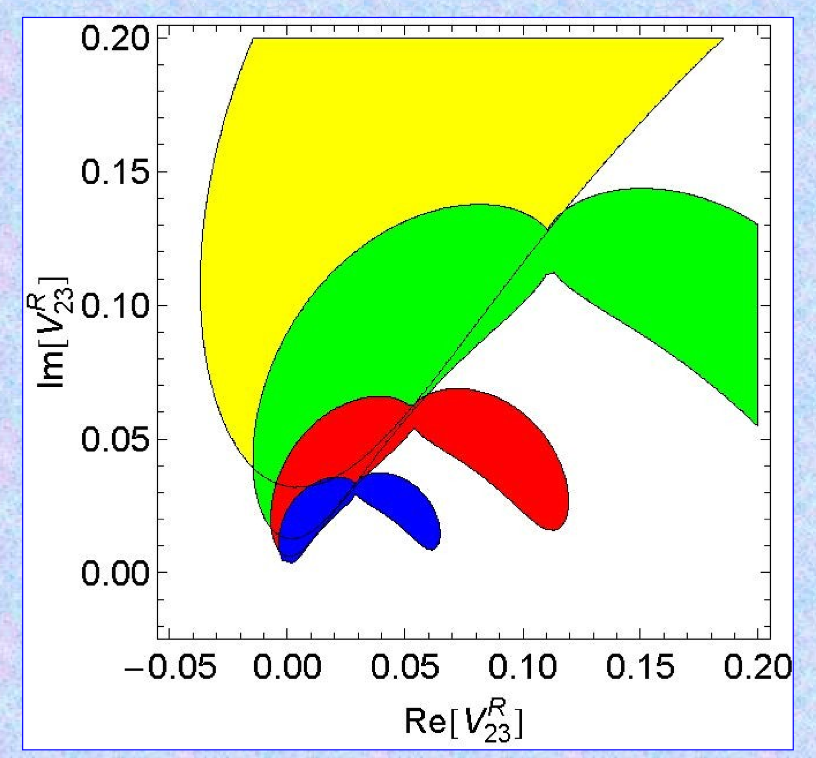
$B_s \to \mu^+\mu^-$

Allowed regions from $B_s \to \mu^+\mu^-$ for different values of ε_b:

- Yellow: $\varepsilon_b = 0.005$
- Green: $\varepsilon_b = 0.01$
- Red: $\varepsilon_b = -0.005$
- Blue: $\varepsilon_b = -0.01$

$$\varepsilon_i^d = \frac{\Sigma_{ii\,Y}^{d\,LR}}{v_u Y^{d_i}}$$

Bs mixing is protected from a Peccei-Quinn symmetry and receives only additional contributions if also $\Delta_{23}^{d\,RL}$ is different from zero.

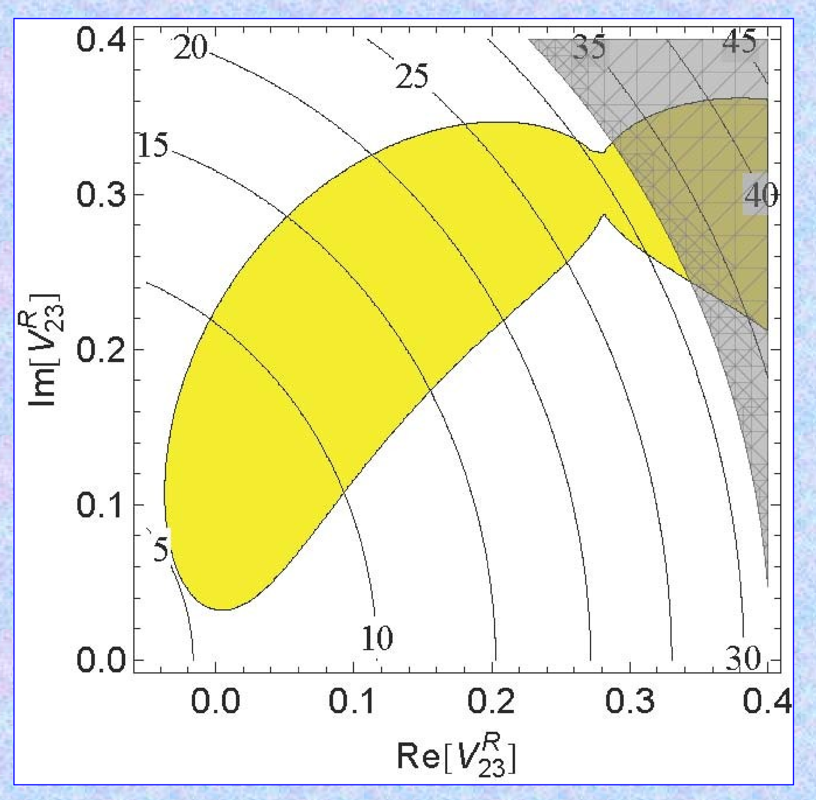


B_s mixing

Allowed regions which can agree with the B_s mixing phase at 2 σ confidence level:

- Yellow: $\tan(\beta) = 11$
- Green: $\tan(\beta) = 14$
- Blue: $\tan(\beta) = 20$
- Red: $\tan(\beta) = 17$

$$V_{23}^R = \frac{\Sigma_{23}^{d\,RL}}{m_b}$$



Correlations between B_s mixing and $B_s \to \mu^+\mu^-$

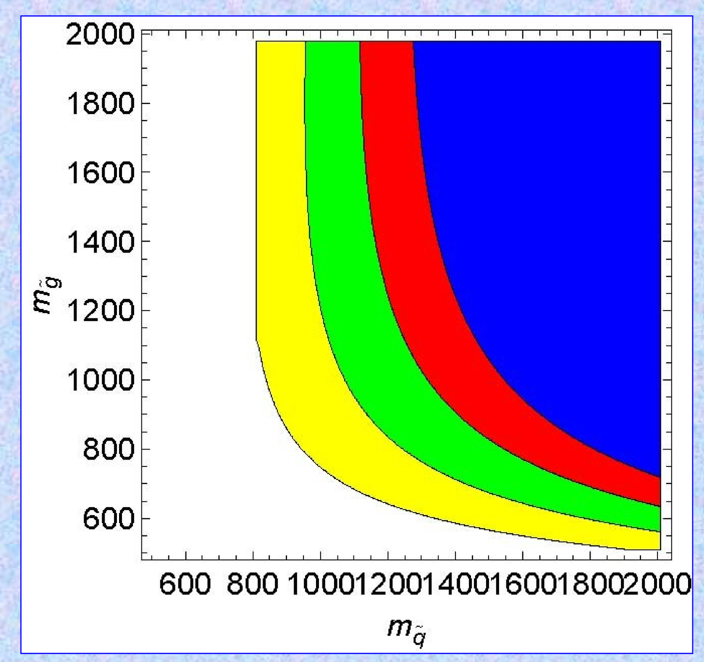
Correlations between B_s mixing and $B_s \to \mu^+\mu^-$. Yellow: allowed region which can explain the B_s mixing phase at 2 σ confidence level. The contour lines label $Br[B_s \to \mu^+\mu^-] \times 10^{-9}$. The gray region is excluded by $B_s \to \mu^+\mu^-$.

CKM generation in the up-sector

For CKM generation in the down sector we require:

$$\Sigma_{13}^{u\,LR} \overset{!}{=} m_t V_{td}^*, \quad \Sigma_{23}^{u\,LR} \overset{!}{=} m_t V_{cb}^*$$

Here the most stringent constraints stem from Kaon mixing which receives additional contributions from chargino diagrams involving the product of mass insertions $\delta_{13}^{u\,LR}\delta_{23}^{u\,LR}$



Kaon mixing

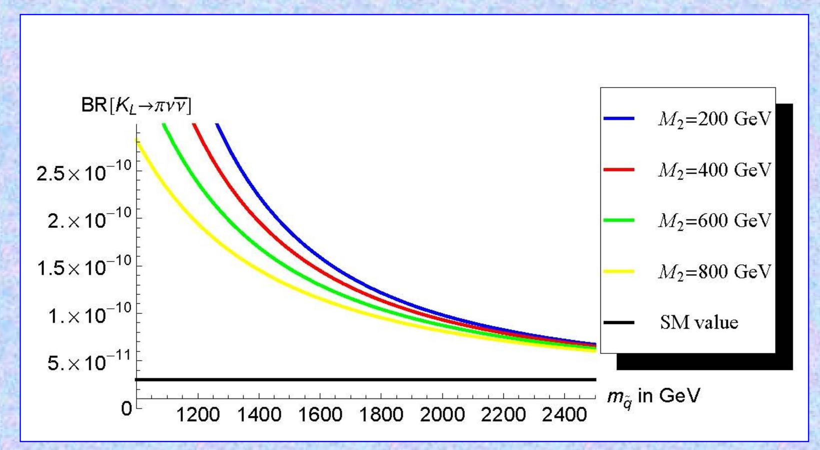
Allowed region from the anomalous magnetic moment of the muon. We require that the SM plus the NP contributions lie within the experimental limits:

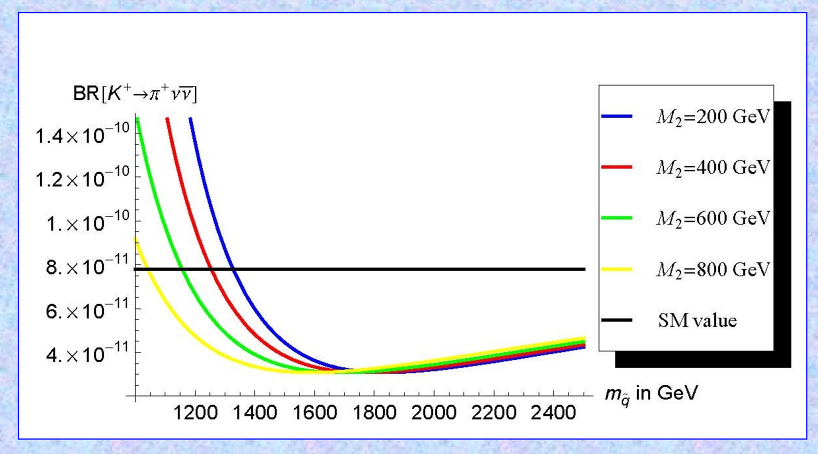
- Blue: $M_2 = 200\,GeV$
- Green: $M_2 = 400\,GeV$
- Red: $M_2 = 400\,GeV$
- Yellow: $M_2 = 800\,GeV$

Also the rare Kaon decays K_L→πνν and $K^+ \to \pi^+$νν receive additional contributions from chagrino-Z penguins.

K→πνν

Predictions for the rare Kaon decay K→πνν in the case of CKM generation in the up-sector.





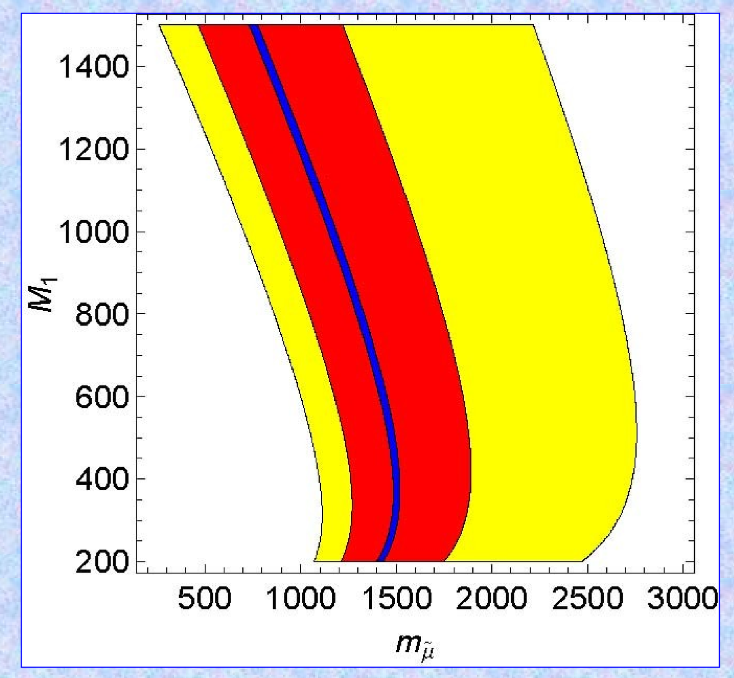
Lepton Sector

In the lepton sector soft Yukawa couplings are probed by the anomalous magnetic moment of the muon which receives additions constructive contributions.

Anomalous magnetic moment of the muon

Allowed region from the anomalous magnetic moment of the muon. We require that the SM plus the NP contributions lie within the experimental limits:

- Red: $\pm 1\sigma$
- Yellow: $\pm 2\sigma$
- Blue: central value



Publications

Supersymmetric renormalisation of the CKM matrix and new constraints on the squark mass matrices.
Andreas Crivellin and Ulrich Nierste. Phys.Rev.D7,2009. arXiv:0810.1613 [hep-ph]

Yukawa coupling and anomalous magnetic moment of the muon: an update for the LHC era.
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Phenomenological consequences of radiative flavor violation in the MSSM.
Andreas Crivellin, Lars Hofer, Ulrich Nierste and Dominik Scherer, arXiv:1105.2818 [hep-ph]