

SUSY-breaking as the origin of flavour violation¹

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The smallness of the off-diagonal CKM elements and of the Yukawa couplings of the first two generations suggests the idea that these quantities are zero at tree-level and might be due to radiative corrections. In the MSSM self-energies involving the trilinear A -terms can lead to order one effects in the renormalization of the CKM elements and the light fermion masses. Thus, these quantities can be generated via loops [2]. This radiative generation of the light fermion masses solves the SUSY CP problem [3, 4] by a mandatory phase alignment between the A -terms and the effective Yukawa couplings.

However, the third generation fermion masses are too heavy to be loop generated and the successful bottom – tau (top – bottom) Yukawa coupling unification in SU(5) (SO(10)) GUTs suggests to keep tree-level third generation fermion masses. Thus we assume the following structure for the Yukawa couplings (and the CKM matrix) of the MSSM superpotential:

$$Y_{ij}^f = Y^{f3} \delta_{i3} \delta_{j3}, \quad V_{ij}^{(0)} = \delta_{ij}. \quad (1)$$

This means that (in the language of [5]) the global $[U(3)]^3$ flavor symmetry of the gauge sector is broken down to $[U(2)]^3 \times [U(1)]^3$ by the Yukawa couplings of the third generation. Here the three $U(2)$ factors correspond to rotations of the left-handed doublets and the right-handed singlets of the first two generation fermions in flavor space, respectively.

The light quark masses and the off-diagonal CKM elements are generated by gluino-squark self-energies which means:

$$\Sigma_{11}^{u,d LR} = m_{u,d}, \quad \Sigma_{22}^{u,d LR} = m_{c,s}, \quad \frac{\Sigma_{13,23}^d LR}{m_b} - \frac{\Sigma_{13,23}^u LR^*}{m_t} = V_{ub,cb}. \quad (2)$$

In the following we consider the limiting case in which the CKM matrix is solely generated by $\Sigma_{13,23}^d LR$ ($\Sigma_{13,23}^u LR$) which we call for obvious reasons CKM generation in the down(up)-sector.

For CKM generation in the down-sector the most stringent constraint stems from an enhancement of $b \rightarrow s\gamma$ due to the off-diagonal element $\Delta_{23}^{d LR}$ in the squark mass

¹Work done in collaboration with Lars Hofer, Ulrich Nierste and Dominik Scherer[1]

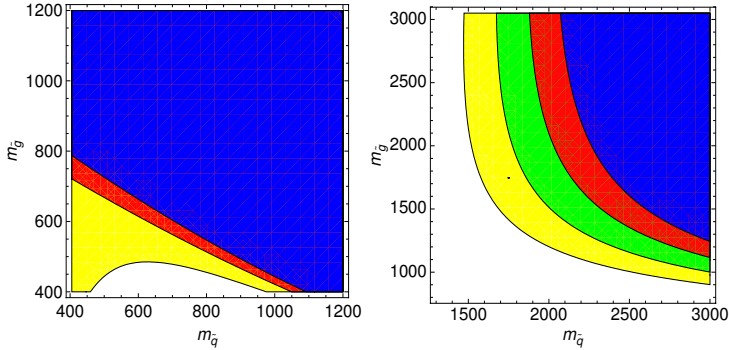


Figure 1: Left: Allowed regions in the $m_{\bar{q}} - m_{\bar{g}}$ plane. Constraints from $b \rightarrow s\gamma$ for different values of $\mu \tan \beta$ assuming that the CKM matrix is generated in the down sector. We demand that the gluino contribution should not exceed the SM one. Yellow(lightest): allowed region for $\mu \tan \beta = 30$ TeV, red: $\mu \tan \beta = 0$ TeV and blue(darkest): $\mu \tan \beta = -30$ TeV. Right: Allowed regions in the $m_{\bar{q}} - m_{\bar{g}}$ plane. Constraints from $K - \bar{K}$ mixing for different values of M_2 assuming that the CKM matrix is generated in the up sector. Yellow(lightest): $M_2 = 1000$ GeV, green: $M_2 = 750$ GeV, red: $M_2 = 500$ GeV and blue(darkest): $M_2 = 250$ GeV.

matrix (left plot of Fig 1). Also $B_s \rightarrow \mu^+ \mu^-$ receives sizable contributions (even in the decoupling limit) from (loop-induced) flavor-changing neutral Higgs couplings [6]. If in addition $\delta_{23}^{dRL} \neq 0$, $B_s - \bar{B}_s$ mixing is affected by double Higgs penguins as well. In this way the $B_s - \bar{B}_s$ mixing phase which disagrees with the SM expectation can be explained and interesting correlations with $B_s \rightarrow \mu^+ \mu^-$ occur (see Fig. 2).

In the case of CKM matrix generation in the up-sector, the most stringent constraints stem from ϵ_K (right plot of Fig. 1) which receives additional contributions via a chargino box diagram involving the double mass insertion $\delta_{23}^{uLR} \delta_{13}^{uLR}$. At the same time the rare Kaon decays $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ and $K_L \rightarrow \pi^0 \nu \bar{\nu}$ receive sizable corrections which is very interesting for NA62.

In conclusion, since the off-diagonal CKM elements and the small quark masses can be generated from loop diagrams while simultaneously obeying all FCNC constraints (for SUSY masses at the TeV scale), the MSSM with RFV is a viable alternative to the popular MFV variant of the MSSM. As opposed to the MFV-MSSM our RFV model is capable to explain the large $B_s - \bar{B}_s$ mixing phase favored by current data.

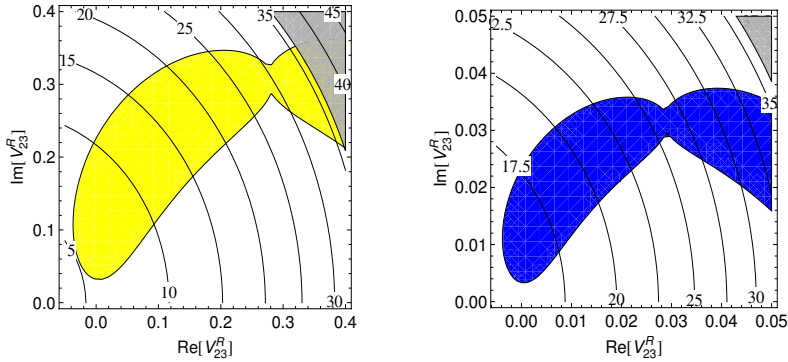


Figure 2: Correlation between $B_s \rightarrow \mu^+ \mu^-$ and $B_s - \bar{B}_s$ mixing for $\epsilon_b = 0.0075$, $m_H = 400\text{GeV}$. Left plot, yellow: Allowed region from $B_s - \bar{B}_s$ mixing (95% confidence level) for $\tan \beta = 11$. The contour-lines show $\text{Br}[B_s \rightarrow \mu^+ \mu^-] \times 10^9$. The grey area at the right side is excluded by the Tevatron bound on $\text{Br}[B_s \rightarrow \mu^+ \mu^-]$. Right plot, blue: same for $\tan \beta = 20$.

References

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