Large CP phase ϕ_s and $\tau \to \mu\gamma$ in SUSY-SU(5)

Prospects at SuperB

J.K.Parry

Kavli Institute for Theoretical Physics China (KITPC),
Beijing, China

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- Correlation of $B_{s(d)}$ mixing and $\tau \longrightarrow \mu(e)\gamma$ in SUSY-SU(5)
- Mass Insertion parameter space allowed by $B_{s,d}$ mixing
- Predictions for $\tau \longrightarrow \mu\gamma$ and prospects at SuperB

$B_{s,d}$ mixing Beyond the SM

Introduction to $B_{s,d}$ mixing

- Define the $\Delta B = 2$ transition between B_q and $\bar{B}_q$,

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- In the Standard Model M_{12}^q is given by,

$$M_{12}^{q,\mathrm{SM}} = \frac{G_F^2 M_W^2}{12\pi^2} M_{B_q} \hat{\eta}^B f_{B_q}^2 \hat{B}_{B_q} (V_{tq}^* V_{tb})^2 S_0(x_t)$$

New Physics and $B_{s,d}$ mixing

- (Model Independent) NP contribution to B_q mixing,

$$\begin{aligned} M_{12}^q &= M_{12}^{q,\mathrm{SM}} (1 + R_q) \\ \Delta M_q &= \Delta M_q^{\mathrm{SM}} |1 + R_q| \\ \phi_q &= \phi_q^{\mathrm{SM}} + \phi_q^{\mathrm{NP}} = \phi_q^{\mathrm{SM}} + arg(1 + r_q\, e^{i\sigma_q}) \end{aligned}$$

where $R_q \equiv r_q\, e^{i\sigma_q} = M_{12}^{q,\mathrm{NP}} / M_{12}^{q,\mathrm{SM}}$

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- Constrain r_q, σ_q from measurement of ρ_q and ϕ_q

$$\begin{aligned} \rho_q &\equiv \frac{\Delta M_q}{\Delta M_q^{\mathrm{SM}}} = \sqrt{1 + 2 r_q \cos\sigma_q + r_q^2} \\ \sin\phi_q^{\mathrm{NP}} &= \frac{r_q \sin\sigma_q}{\sqrt{1 + 2 r_q \cos\sigma_q + r_q^2}}, \end{aligned}$$

$B_{s,d}$ mixing in SUSY P.Ball, S.Khalil, E.Kou Phys. Rev. D **69** (2004) 115011

- Dominant SUSY contribution comes from gluino,

$$\begin{aligned} R_q^{\tilde{g}} &= a_1^q(m_{\tilde{g}}, x)\left[(\delta_{q3}^d)_{RR}^2 + (\delta_{q3}^d)_{LL}^2\right] \\ &+ a_4^q(m_{\tilde{g}}, x)(\delta_{q3}^d)_{LL}(\delta_{q3}^d)_{RR} + \ldots \end{aligned}$$

where $x = m_{\tilde{g}}^2/m_{\tilde{q}}^2$,

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$$R_q^{\tilde{g}} \equiv r_q\, e^{i\sigma_q} = M_{12}^{q,\tilde{g}}/M_{12}^{q,\mathrm{SM}}$$

  and
- Total contribution is then,

$$\Delta M_q = \Delta M_q^{\mathrm{SM}}\,|1 + R_q^{\tilde{g}}|$$

Quark-Lepton correlations in SUSY-SU(5)

Properties of SU(5)

- Reps: $\mathbf{10}_i = (Q, U_R, e_R)_i, \bar{5}_i = (L, D_R)_i$

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MI relations at GUT scale

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- Relationship survives to EW scale and means there is a correlation between B mixing and LFV τ decays

Correlations in SUSY-SU(5)

LFV decay rate

$$BR(\tau \to l_i \gamma) \simeq \frac{\alpha^3}{G_F^2} \frac{m_{\tilde{l}}^4}{M_S^8} |(\delta^l_{i3})_{LL}|^2 \tan^2 \beta$$

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SUSY contribution to $B_{s,d}$ mixing

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- CKM RGE effects fix δ_{LL}^d,

$$(\delta_{ij}^d)_{LL} \approx -\frac{1}{8\pi^2} Y_t^2\, V_{ti}^* V_{tj} \frac{(3m_0^2 + A_0^2)}{m_{\tilde{d}}^2} \ln \frac{M^*}{M_W}$$

Numerical results

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J. K. Parry and H. h. Zhang, Nucl. Phys. B **802** (2008) 63

Numerical Inputs

$$\begin{aligned} \tan\beta &= 10 \\ m_0 &= 220\,GeV, 600\,GeV \\ M_{1/2} &= 180\,GeV \\ A_0 &= 0 \\ m^2_{\tilde{d}} &\approx m_0^2 + 6M_{1/2}^2 \\ m^2_{\tilde{l}} &\approx m_0^2 \\ m_{\tilde{g}} &\approx 3M_{1/2} \end{aligned}$$

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- First determine the allowed δ^d_{RR} parameter space
- Predict LFV rates in the SUSY-SU(5)

B physics constraints

Experimental Results at 90% C.L. CDF, D∅, BaBar, Belle, UTfit, HFAG

$$\rho_d \equiv \Delta M_d^{\rm exp}/\Delta M_d^{\rm SM} = [0.53,\ 2.05]$$
$$\phi_d = [-16.6,\ 3.2]^o$$
$$\rho_s \equiv \Delta M_s^{\rm exp}/\Delta M_s^{\rm SM} = [0.62,\ 1.93]$$
$$\phi_s = [-171.89,\ -107.72]^o \cup [-72.19,\ -7.45]^o$$

LFV constraints

Experimental Constraints BaBar, Belle, SuperB

$$
\begin{aligned}
Br(\tau \to \mu\gamma) &\leq 4.5 \times 10^{-8} \\
Br(\tau \to \mu\gamma) &\lesssim 2 \times 10^{-9} \quad (SuperB) \\
Br(\tau \to e\gamma) &\leq 1.1 \times 10^{-7} \\
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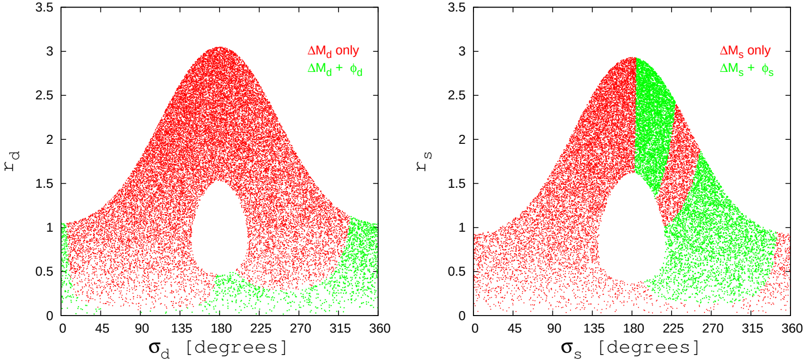
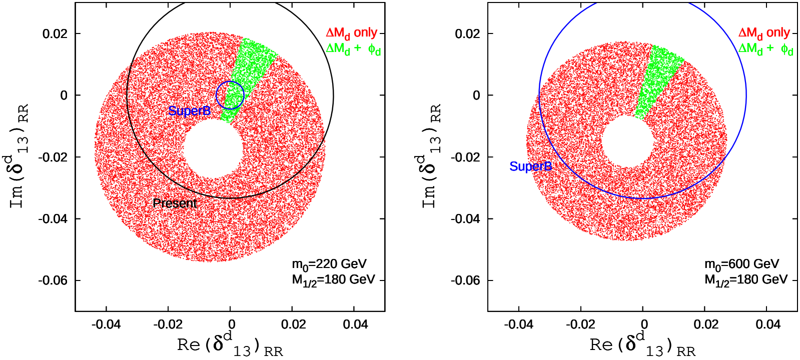
\end{aligned}
$$

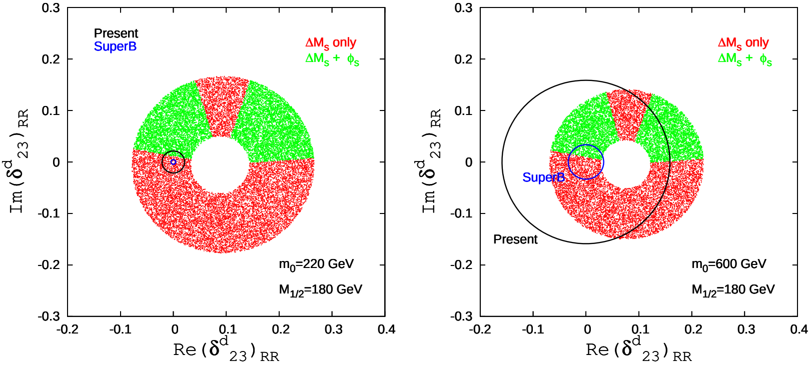
$R_q = r_q\, e^{i\,\sigma_q}$ parameter space



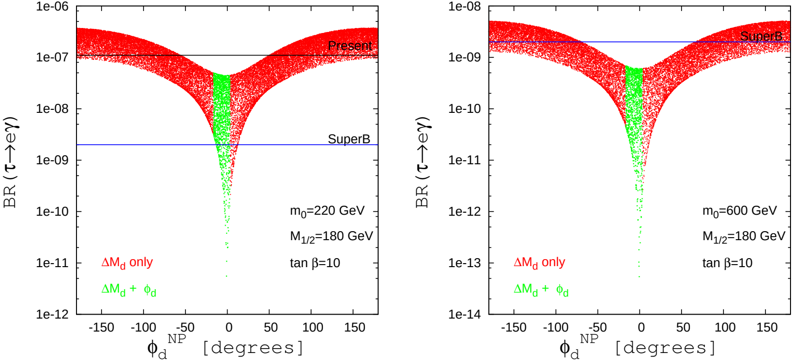
Mass Insertion $(\delta^d_{13})_{RR}$ and $\tau \to e\gamma$



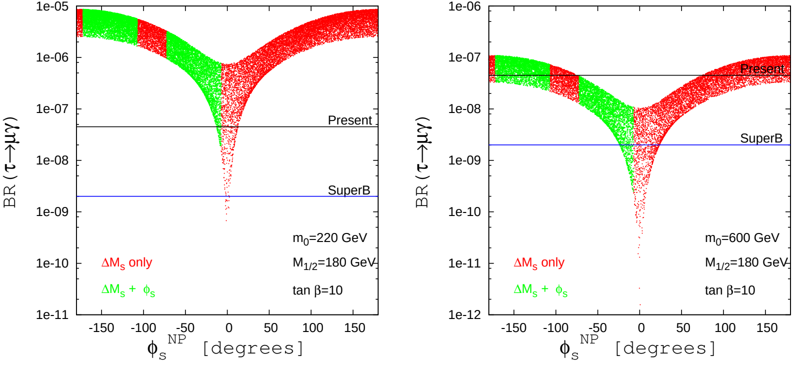
Mass Insertion $(\delta^d_{23})_{RR}$ and $\tau \to \mu\gamma$



Prediction for $Br(\tau \to e\gamma)$



Prediction for $Br(\tau \to \mu\gamma)$



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- In SUSY-SU(5) the large phase ϕ_s indicates large $\tau \to \mu\gamma$
- SuperB's search for τ LFV decays can tell us about SUSY-GUT parameter space or even rule out models