Neutrino Yukawa couplings and FCNC processes in B decays in SUSY-GUT

Toru Goto (KEK)

with S. Baek (KEK)

Y. Okada (KEK)

K. Okumura (ICRR, U-Tokyo)

S. Baek, T. Goto, Y. Okada & K. Okumura,

hep-ph/0002141

Introduction

Beyond SM via flavor physics

- Quark : CKM consistency

  $|V_{ub}|$, $B_d - \bar{B}_d$, ε_K $\oplus$ { $A_{CP}(B \to J/\psi K_S)$; $B_s - \bar{B}_s$ mixing } $\to (\rho, \eta)$

- Lepton : LFV ($\mu \to e\gamma$, $\tau \to \mu\gamma$)

  Observed (?) = ν oscillation { atm. ; sol. }

★ small ν mass $\leftrightarrow$ { heavy ν_R ; (O(1)) Yukawa coupling }

see-saw

In SU(5) SUSY GUT,

- CKM mixing in q_L $\xrightarrow{\text{GUT}}$ LFV in $\tilde{e}_R$

  (top Yukawa)

  10 of SU(5)

  Barbieri - Hall ('94) ...

This work:

- MNS mixing in ℓ_L $\xrightarrow{\text{GUT}}$ mixing in $\tilde{d}_R$

  Maki - Nakagawa - Sakata ('62) (ν Yukawa)

  $\bar{5}$ of SU(5)

$\Rightarrow$ new source of flavor mixing for B & K observables.

Model : minimal SU(5) SUSY GUT $\oplus \nu_R$

@ M_{Planck} universal soft ~~SUSY~~ (mSUGRA)

↓

@ M_{GUT} $SU(5) \to SU(3) \times SU(2) \times U(1)$

↓ MSSM + ν_R $\quad W_\nu = f_N^{ij} N_i L_j H_2 + \frac{1}{2} M_\nu^{ij} N_i N_j$

@ $M_R \sim M_\nu$ $\quad \kappa = f_N^T M_\nu^{-1} f_N$

↓ MSSM $- \frac{1}{2} \kappa^{ij} (L_i H_2)(L_j H_2)$

@ μ_{EW}

$m_\nu = - \kappa \langle H_2 \rangle^2$

• squark / slepton mass @ M_{GUT}

$$m_{10}^2 \approx m_0^2 \left[\mathbb{1} - \text{◍} \, f_U f_U^\dagger \log \frac{M_P}{M_G} + \cdots \right]$$

$$m_{\bar{5}}^2 \approx m_0^2 \left[\mathbb{1} - \text{▨} \, f_N^\dagger f_N \log \frac{M_P}{M_G} + \cdots \right]$$

determine mass bases of squarks / sleptons.

SU(5) embedding of fermions

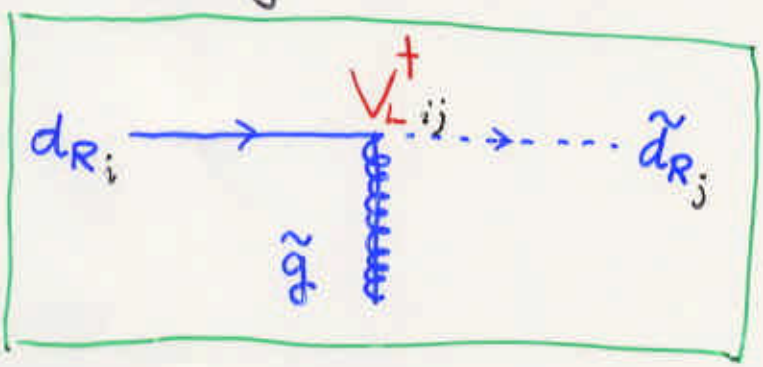
★ $10 \sim \left[u_R^c \,,\, \begin{pmatrix} u_L \\ V_{KM} d_L \end{pmatrix} \,,\, V_{KM} e_R^c \right]$

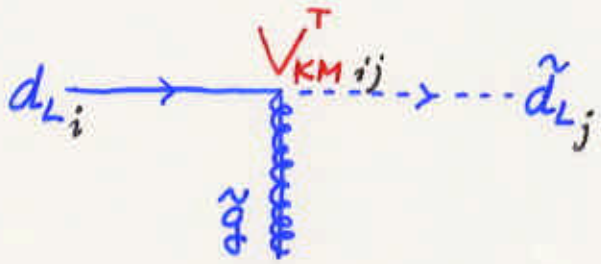
(*) $\tilde{f}_D = \tilde{f}_L$ @ M_{GUT}

★ $\bar{5} \sim \left[V_L d_R^c \,,\, V_L \begin{pmatrix} e_L \\ V_{MNS} \nu_L \end{pmatrix} \right]$

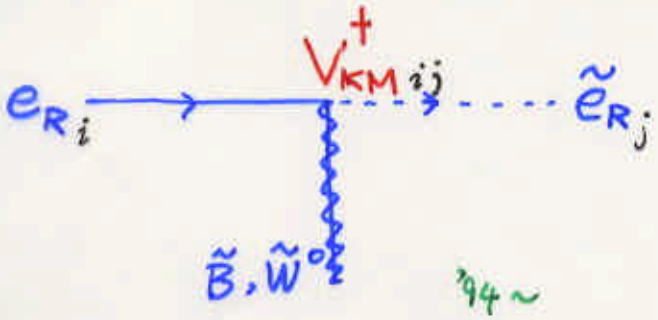
$$\begin{cases} V_L f_N^\dagger f_N V_L^\dagger = \text{diag.} \\ V_{MNS}^T f_N^T M_\nu^{-1} f_N V_{MNS} = \text{diag.} \end{cases}$$

→ squark/slepton mass matrices are diagonal @ bases ★.

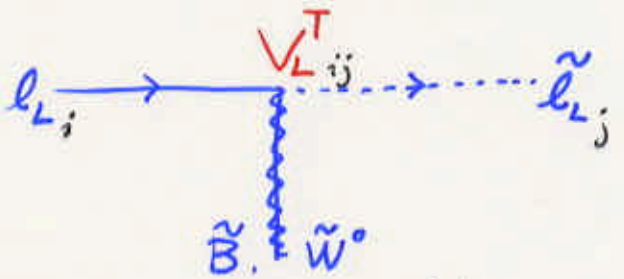




80's ~



'94 ~



90's ~

Numerical Results

Simplification

$M_\nu = M_R \times \mathbb{1}$, f_N : real $\longrightarrow$ $V_L = V_{MNS}^\dagger$ @ $M_R = 4\times10^{14}$ GeV

$m_0, m_{1/2} < 1$ TeV, $|A/m_0| < 5$ scanned.

- ν mixing parameters :

★ $\sin^2 2\theta_{23} = 1$ (atm.ν), $\sin^2 2\theta_{13} = 0$ (CHOOZ)

(i) $\sin^2 2\theta_{12} = 5.5\times10^{-3}$ (small mix. MSW) (for sol. ν)

- weak constraint from $B(\mu \to e\gamma)$
- possible enhancement of $B(\tau \to \mu\gamma) \sim 10^{-7}$
- " Δm_S, $A_{\ell}^{CP}(b\to s\gamma)$

(ii) $\sin^2 2\theta_{12} = 1$ (large mix. MSW)

- strong constraint from $B(\mu\to e\gamma)$
- large contribution to ε_K

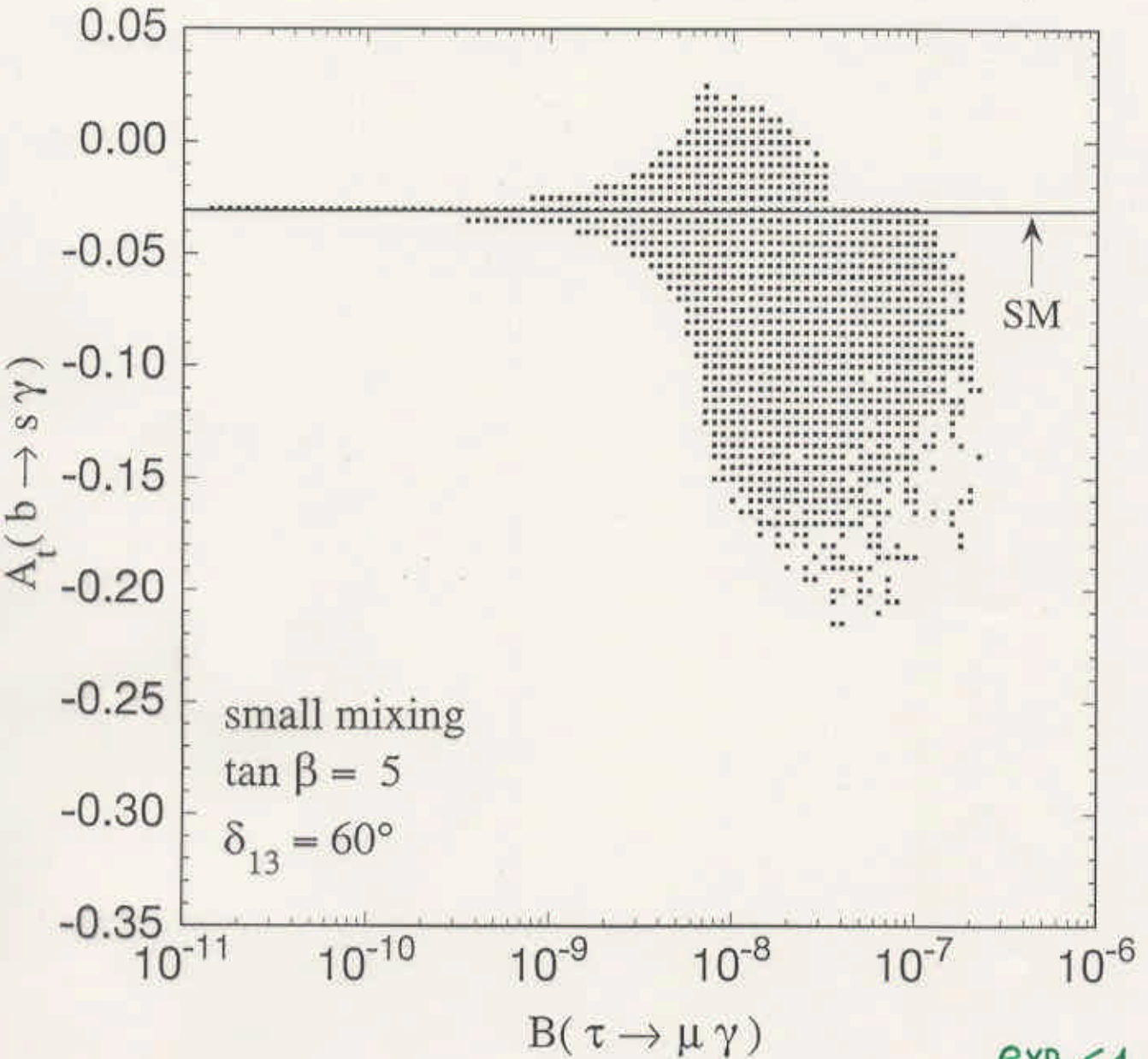
→ allowed region of $\delta_{13}(\phi_3)$ modified.

$\Delta m_S/\Delta m_d$, $A^{CP}(B\to J/\psi K_S)$ affected.

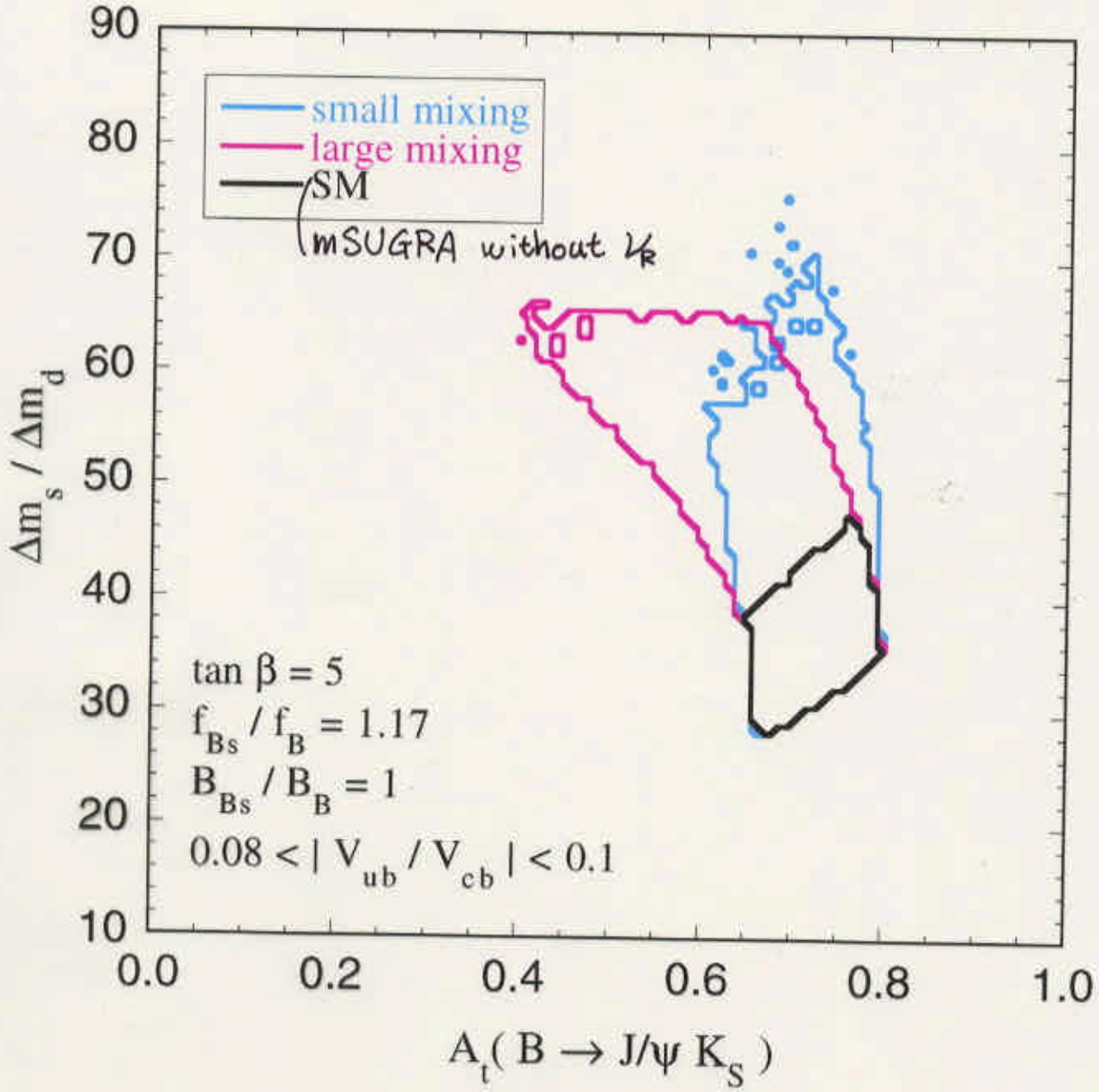
$$\frac{\Gamma(B^0(t) \to M_S \gamma) - \Gamma(\bar{B}^0(t) \to M_S \gamma)}{+} = \xi_S A_t \sin(\Delta m_d t)$$

CP eigenstate $\begin{cases} K_1 \to \rho^0 K_S \\ K^* \to \pi^0 K_S \end{cases}$

eigenvalue (± 1)



exp. $< 1.1 \times 10^{-6}$



dmbsd-AtJKs.05a.eps

20000302

Conclusion

FCNC (ε_K, $\frac{\Delta m_s}{\Delta m_d}$, $b \to s\gamma$) studied in SU(5) SUSY-GUT $\oplus \nu_R$.

★ ν mixing (V_{MNS}) $\xrightarrow{GUT}$ $\tilde{d}_R$ mixing

= new source of (quark) flavor mixing besides V_{KM} in mSUGRA.

→ possible deviation (mismatch) in combined SM analysis of $A_t(B \to J/\psi K_S)$, $\frac{\Delta m_s}{\Delta m_d}$, ε_K, $|V_{ub}|$.

→ enhancement of $A_t(b \to s\gamma)$.

★ more free parameters for $V_L \neq V_{MNS}^{\dagger}$ ($M_\nu \not\propto \mathbb{1}$) case .....