SUSY '02

DESY, JUNE 2002

QUARK FLAVORS and CP $\neq$

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FLAVOUR PROBLEM: STATUS & MESSAGE

- ε
- V_{ub}/V_{cb}
- Δm_d
- $\sin 2\beta_{J/\psi K_s}$
- $\Delta m_s/\Delta m_d$

$\Rightarrow$ ρ, η

"redundant" determination of the unitarity triangle

+

"rare" processes: $b \to s+\gamma$, $\mu \to e+\gamma$, d_n^e, d_e^e, Δm_D, ...

(tests of GIM, CP≠, LFV ...)

$\Downarrow$

CONVERGENCE OF ALL FLAVOUR RESULTS TO THE SM EXPECTATIONS

$\Rightarrow$ FLAVOUR BLINDNESS OF NEW PHYSICS

NOVELTIES IN FLAVOR PHYSIC

in the last few years

- ν OSCILLATIONS
  (in particular, large ν mixing in atm. ν's)

- $\varepsilon' \neq 0$ ("large" ε'/ε)

- $\sin 2\beta \neq 0$ (CP$\not$ in B physics)

IMPLICATIONS FOR NEW PHYSICS

ν OSC. $\Longrightarrow$ new physics originates ν masses and the large ν mixing in the 2-3 sector

"large" ε' $\Longrightarrow$ new physics can possibly account for the "large" ε' (but it is and, probably, it wi[ll] be unclear whether the SM is not able to reproduce the exp. value of ε')

$\sin 2\beta$ $\Longrightarrow$ agreement of $\sin 2\beta$ as determined from $a_{J/\psi K_S}$ with the SM, but it is possible that new physics modifies other CP$\not$ B decays (involved with β, γ

ORIGIN of FLAVOR

⇕

SUSY BREAKING

NO RELATION
SUSY BREAKING
IS FLAVOR BLIND

(ex.: GMSB, AMSB, pure dilaton breaking, ...)

⇓

- still NEW SOURCES OF CP̸ (at least 2 CP̸ phases - unrelated to the flavor structure)
- CKM + exchange of SUSY particles (light $\tilde{t}-\tilde{\chi}$)
- LARGE RGE effects spoiling flavor universality (ex. SUSY GUTs)

SUSY BREAKIN
KNOWS FLAVOR

⇓

SUSY breaking ter introduce a **NEW FLAVOR STRUCTU** in addition to th Yukawa flavor struc of the SM

$A \Rightarrow A_{ij} \not\propto h_{ij}$

$\tilde{m} \to \tilde{m}_{ij} \not\propto \delta_{ij} \tilde{m}$

Bartl, Gajdosik, Lunghi, A.M., Porod, Stockinger, Stremnitzer, Vives: mSUGRA and minimal SU(5) (with 2-loop RGE for running $M_{GUT} \to M_W$)

light $\tilde{t}$ mass

in mSUGRA

chargino mass

in SUSY SU(5)

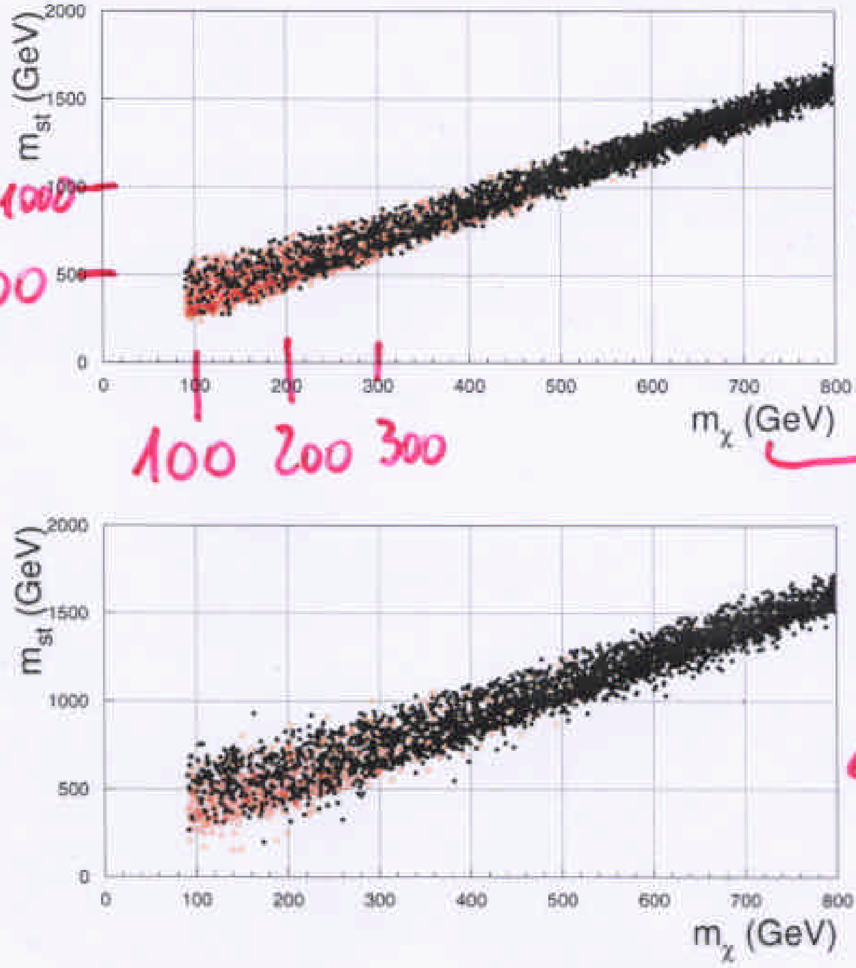


Figure 1: Chargino mass versus lightest stop mass as for the parameter space described in the text in the CMSSM and SU(5) cases.

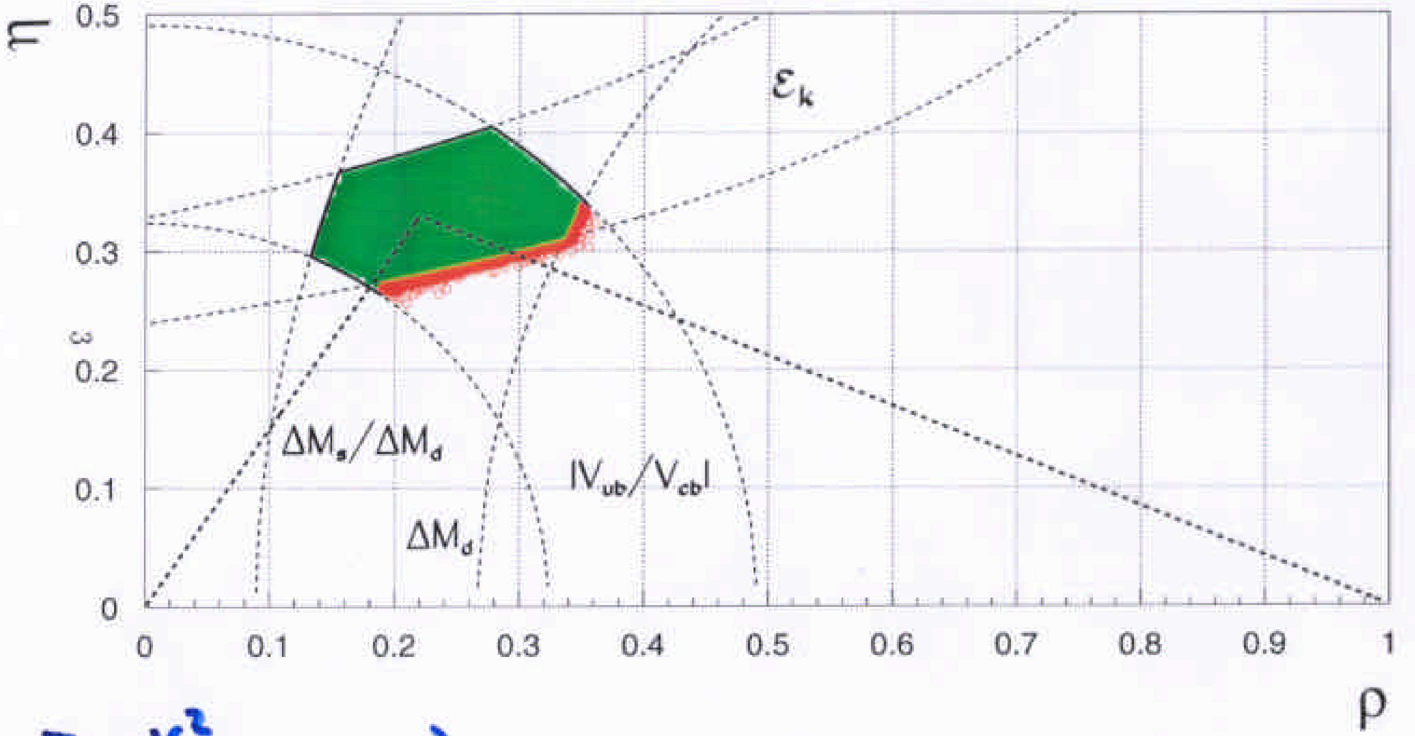
for $m_\chi = 100$ GeV $\Rightarrow$ 240 GeV $< m_{\tilde{t}_1} <$ 660 GeV

(in mSUGRA)

with 10^2 GeV $< m_0 < 1$ TeV

BARTL et al.

- red dots: departure from SM due to the exchange of mSUGRA particles



$$\left.\begin{array}{l} \varepsilon_K \rightarrow \mathrm{Im}\, V_{td}^2 \\ \Delta m_d \rightarrow \mathrm{Re}\, V_{td}^2 \\ a_{J/\psi K_S} \rightarrow \mathrm{Im}\, V_{td} \end{array}\right\} \Rightarrow V_{td} \qquad V_{ub}$$

MSSM without new flavor structure but with new, large CP ≠ phases

(d_n^e tamed by cancellations among different contributions)

Ibrahim, Nath; Brhlik, Good, Kane; Brhlik, Everett, Kane, Lykken; Accomando, Arnowitt, Dutta

GENERAL MSSM with $\delta_{CKM} = 0$

WITH ALL POSSIBLE PHASES IN THE SOFT BREAKING TERMS

$$\left(A_U e^{i\varphi_{A_U}}, \quad A_D e^{i\varphi_{A_D}}, \quad A_E e^{i\varphi_{A_E}}, \right.$$
$$\left. m_{\tilde{g}} e^{i\varphi_3}, \quad m_{\tilde{W}} e^{i\varphi_2}, \quad m_{\tilde{B}} e^{i\varphi_1}, \quad \mu = |\mu| e^{i\varphi_\mu} \right)$$

BUT **NO NEW FLAVOR STRUCTURE** in addition to the usual Yukawa matrices

DEMIR, A.M., VIVES

IT IS NOT POSSIBLE TO GIVE SIZABLE CONTRIBUTIONS TO ε, ε'/ε, HADRONIC B^0 CP ASYMMETRIES

(only $A_{CP}^{b\to s\gamma}$, isospin violation in $B \to \rho\gamma$ Ali; Handel, London

if some new flavor structure is present (even if phases flavor inde

$\Rightarrow$ possibly large effects Brhlik, Everett, Kane, King, Lebedev

LEPTON FLAVOR $\neq$

Yanagida; Gell-Mann, Ramond, Slansky; Mohapatra, Senjanovic

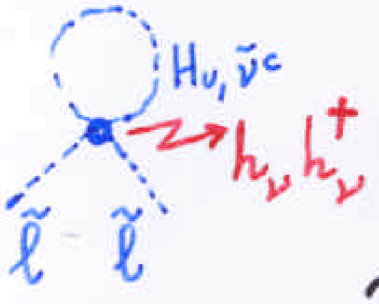
Ex: SUSY SEE-SAW MECHANISM

Borzumati, A.M.; Leontaris, Tamvakis, Vergados;

in SUSY SU(5) Barbieri, Hall; Barbieri, Hall, Strumia;

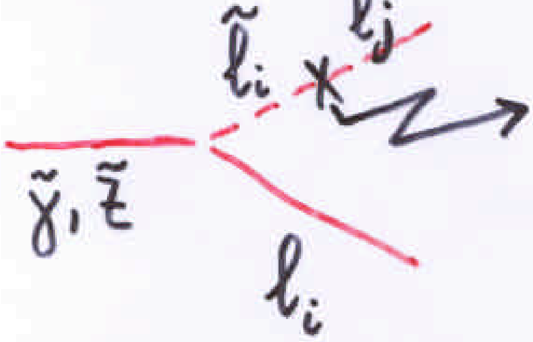
Hisano, Nomura, Yanagida; Hisano, Moroi, Tobe, Yanagida; Moroi; Carvalho, Ellis, Gomez, Lola

$$W = h_L L H_d e^c + h_\nu L H_u \nu^c + M \nu^c \nu^c$$



$$M_{\tilde{\ell}_L \tilde{\ell}_L^+} = \tilde{m}^2 \mathbb{1} + m_\ell m_\ell^+ + c\, m_\nu^D m_\nu^{D+}$$

$$m_\nu^D = h_\nu \langle H_u \rangle$$



$$\Delta^\ell_{ij} = c \left(U m_\nu^D m_\nu^{D+} U^+ \right)_{ij}$$

diagonalizes $m_\ell m_\ell^+$

for $m_\nu^D \sim 10-20$ GeV and $U \sim K_{CKM}$

$$BR(\mu \to e\gamma) \sim 10^{-12} \div 10^{-13}$$

and also μ-e conversion in nuclei close to the exp. bound

link between neutrino mass textures $\to \mu \to e\gamma$ in SUSY — CASAS et al.; Lavignac et al.

$\tau \to \mu\gamma$ Blazek

neglecting phases

$$U_{HNSP} \sim \begin{pmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 0 & -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{pmatrix}$$

single maximal mixing (in the ν_{atm} sector)

$$U_{HNSP} \sim \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -\frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ \frac{1}{2} & -\frac{1}{2} & \frac{1}{\sqrt{2}} \end{pmatrix}$$

bimaximal mixing (if also large mixing in ν_{solar} → now LMA in MSW is slightly favoured by the data)

CASAS, IBARRA
LAVIGNAC, MASINA, SAVOY; in SO(10) BUCHMULLER, WYLER
CARVALHO, ELLIS, GOMEZ, LOLA

$$\Rightarrow \left(Y_\nu^+ Y_\nu\right)_{ij} \simeq M\left[\frac{m_{\nu_2}}{v_u^2} U_{i2} U_{j2}^* + \frac{m_{\nu_3}}{v_u^2} U_{i3} U_{j3}^*\right]$$

$$\left|\left(Y_\nu^+ Y_\nu\right)_{23}\right| \sim \left|M \frac{m_{\nu_3}}{v_u^2} U_{23} U_{33}^*\right| \sim \frac{1}{2} |Y_0|^2$$

$|Y_0|^2 \rightarrow$ largest eigenvalue of $Y_\nu^+ Y_\nu$

$$\left\|Y_0(M_x)\right\| = \left|Y_t(M_x)\right|$$

unif. condition

$t-\nu_\tau$ unif. (in addition to $b-\tau$ unif.)

SO(10) with $\begin{cases} 16 \cdot 16 \ 10_u \Rightarrow M_U = M_\nu^{DIRAC} \\ 16 \cdot 16 \ 10_d \Rightarrow M_d = M_\ell \end{cases}$

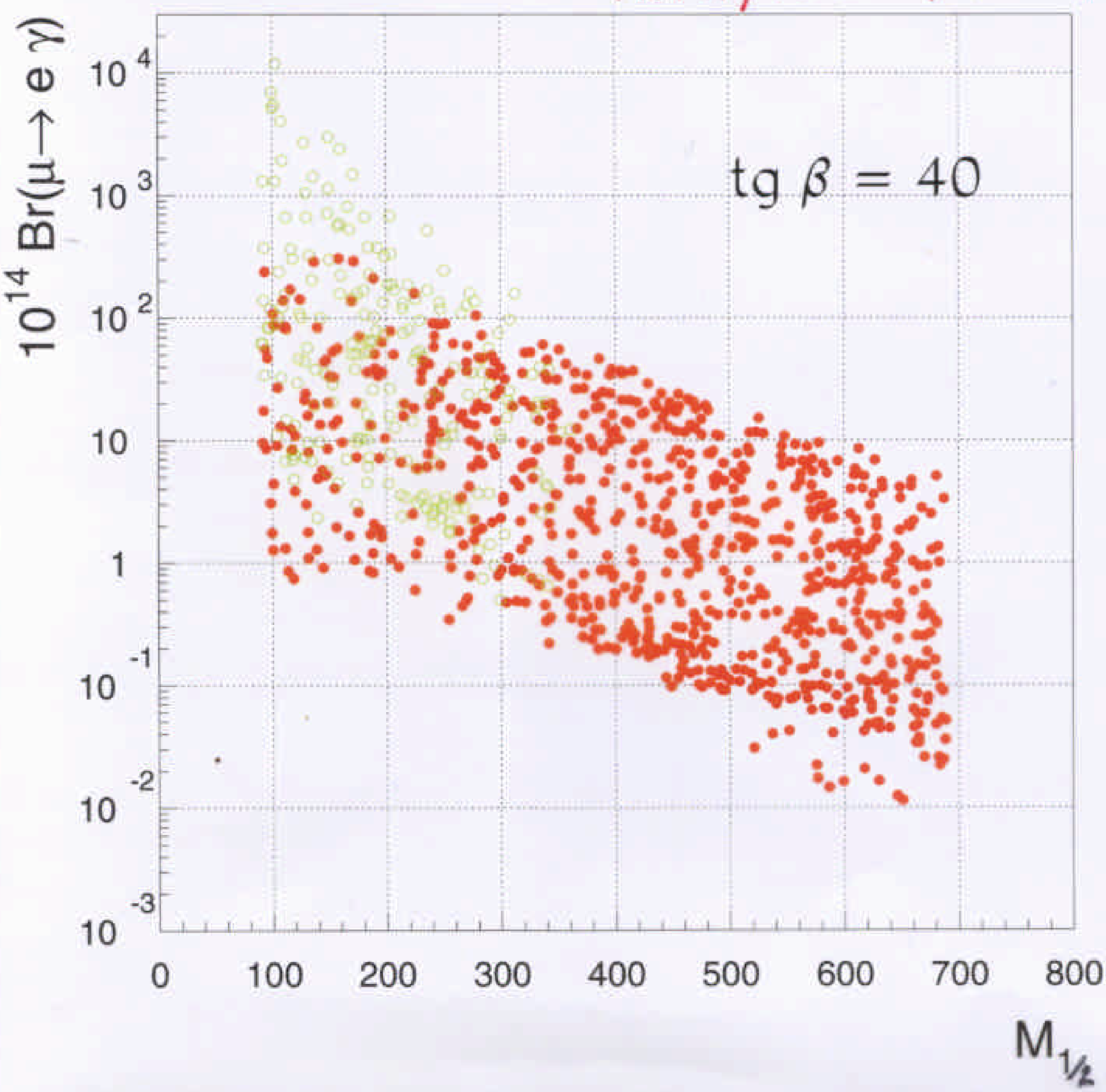
$\Rightarrow$ "pessimistic" case when

M_ν^{DIRAC} diagonalized by CKM matrix

$\rightarrow$ large U_{MNSP} angles due to M_R structure

$\Rightarrow$ $\ell_i \to \ell_j + \gamma \propto$ CKM entries and h_t

A.M., VEMPATI, VIVES (in preparati



So far:

LARGE ν MIXING

$+$

LARGE Y_ν

$\Rightarrow$ LARGE Δ^{ℓ}_{LL}

significant effects in LFV physics

Now: add LEPTON-QUARK UNIFICATION

example: $SU(5)$ $d^c \leftrightarrow \nu$ MORO1 p0104263

$SO(10)$ $u \leftrightarrow \nu$ CHANG, A.M., MURAYA

[redacted]

$\Longrightarrow$ LARGE Δ^{ℓ} TRANSLATES INTO

LARGE Δ^{d}

$\rightarrow$ large $(\delta^{\ell}_{LL})_{23}$ $\rightarrow$ large $(\delta^{d}_{RR})_{23}$

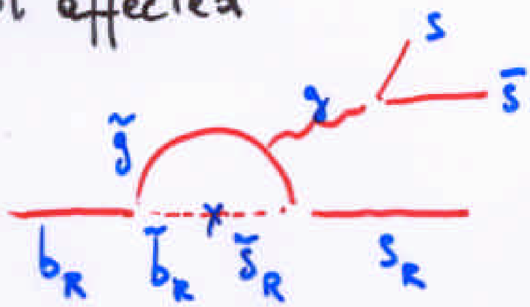
$\Rightarrow$ effects for B physics

IMPLICATIONS OF A LARGE $(\delta^d_{23})_{RR}$ (with possibly a large phase) Chang, A.M., Murayama

- ΔM_s : ΔM_s^{SUSY} becomes comparable to ΔM_s^{SM}
- $b \to s\gamma$: no sizeable effect
- effects on $\sin 2\beta$:

$B_d \to J/\psi K_s$ not affected

$B_d \to \phi K_s$

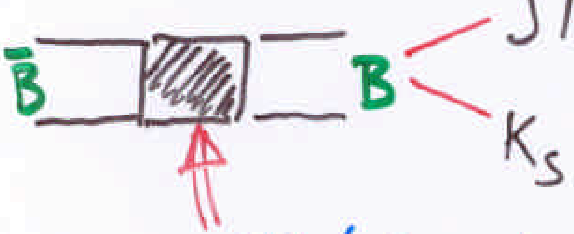


from Ciuchini et al. for $(\delta^d_{23})_{RR} \simeq 1$

$$\frac{A^{SUSY}_{B\to\phi K_s}}{A^{SM}_{B\to\phi K_s}} \;\begin{cases} 0.7 & \text{for } \tilde m \sim 250 \text{ GeV} \\ 0.2 & \text{for } \tilde m \sim 500 \text{ GeV} \end{cases}$$

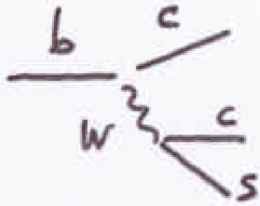
$\Rightarrow$ if $(\delta^d_{23})_{RR}$ has also a large phase: $\sin 2\beta$ measured from $B \to J/\psi K_s$ and $B \to \phi K_s$ could differ as much as 50% due to the new SUSY contributions

SIGNALS FOR SUSY in $\sin 2\beta$



$a_{J/\psi K_S}$

CP≠ in mixing ⇒ phase ϕ_M

interference of  with tree level 

but in $b \to s s \bar{s}$ interf. of  with 

if $\tilde{b}$ - - - × - - $\tilde{s}$ → COMPLEX given that $\frac{A_{SUSY}}{A_{SM}} \simeq 0.4 \div 0.7$

⇒ possible to have "$\sin 2\beta$" very different from the $\sin 2\beta$ measured in $B \to J/\psi K_S$

COMPARING "$\sin 2\beta$" from

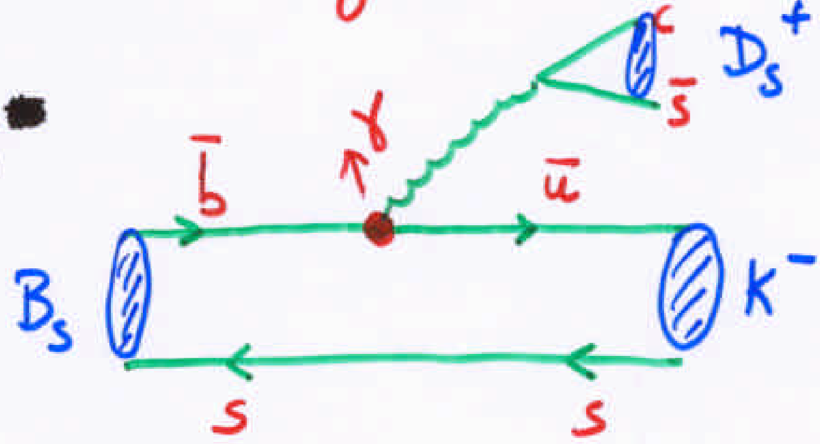
$B_d \to J/\psi K_S$, $B_d \to D^0 \pi^0$ as in SM

$B_d \to \phi K_S$, $B_d \to \pi^0 K_S$ can be ≠ from SM if $\tilde{b}$ - × $\tilde{s}$ - large

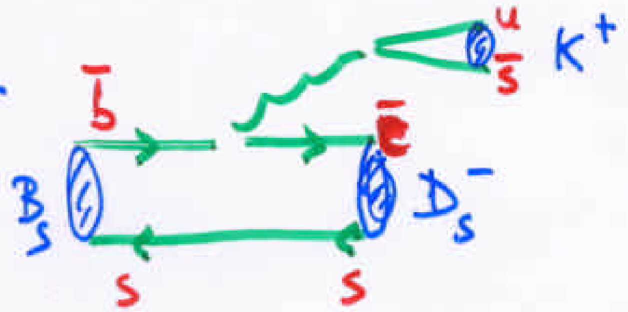
Ciuchini, Franco, Martinelli, A.M., Silvestrini ; Grossman, Worah ; Barbieri, Strumia

EFFECTS OF A LARGE $(\delta^d_{23})_{RR}$ on the DETERMINATION OF γ

1) $B_s \to D_s^+ K^-$



$B_s \to D_s^- K^+$



B_s can reach $D_s^+ K^-$ either through the $b\bar{u}$ vertex or first oscillating to $\bar{B}_s$ with $\bar{B}_s$ then decaying into $D_s^+ K^-$ via a normal $b\bar{c}$ vertex

SM: $$\frac{\overset{\gamma}{A(B_s \to D_s^+ K^-)}}{\underset{\text{no phase}}{A(B_s - \bar{B}_s)}\ \underset{\text{no phase}}{A(\bar{B}_s \to D_s^+ K^-)}} \Rightarrow \gamma$$

SUSY + SM :

$$\frac{A(B_s \xrightarrow{\gamma} D_s^+ K^-)}{A(B_s - \bar{B}_s)\, A(\bar{B}_s \to D_s^+ K^-)}$$

$2\varphi_\delta$

if $(\delta_{23}^d)_{RR} = |(\delta_{23}^d)_{RR}|\, e^{i\varphi_\delta}$

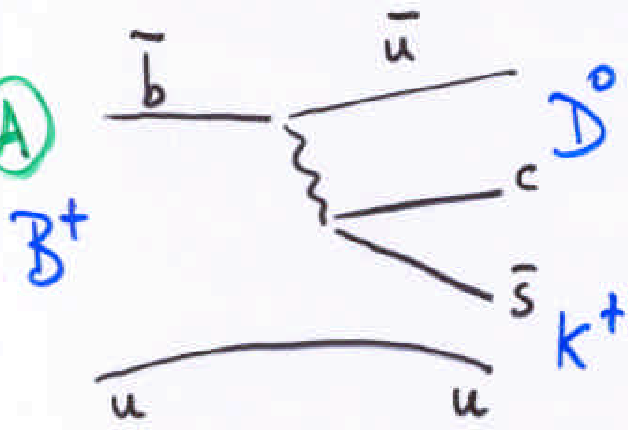
$$A(B_s - \bar{B}_s) = A^{SM}(B_s - \bar{B}_s)\left(1 + \frac{b_{ox}^{SUSY}}{b_{ox}^{SM}}\, e^{2i\varphi_\delta}\right)$$

if $(\delta_{23}^d)_{RR}$ large $b_{ox}^{SUSY} \sim b_{ox}^{SM}$

$\Rightarrow$ for large $|(\delta_{23}^d)_{RR}|$ and large φ_δ the determination of "γ" from $B_s \to D_s^+ K^-$ can be strongly affected by $\mathrm{Im}\,(\delta_{23}^d)_{RR}$

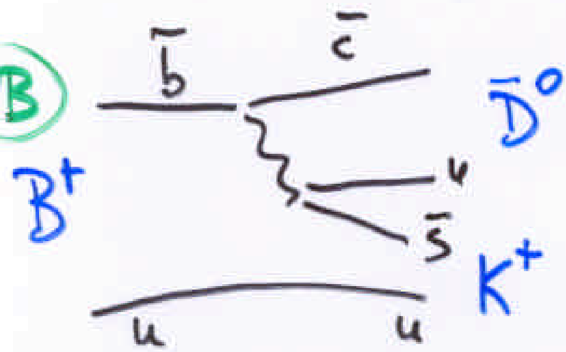
2) $B^\pm \to D^0 K^\pm$

Ⓐ



expected BR $\sim 2 \cdot 10^{-6}$

Ⓑ



$B^+ \to \bar{D}^0 K^+$

expected BR $\sim 2 \times 10^{-4}$

in $B^+ \to D_{CP} K^+$ interference of Ⓐ and Ⓑ

$\Longrightarrow \gamma$

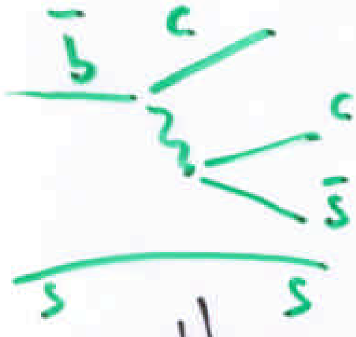
Here No SUSY contribution

"γ" as determined from $B^+ \to D^0 K^+$ and from $B_s \to D_s^+ K^-$ would be quite differ[ent] for large $(\delta_{23}^d)_{RR}$

STRIKING EFFECT OF A LARGE COMPLEX $(\delta^d_{23})_{RR}$

CP$\not=$ in some B decays which are expected to be essentially CP conserving in the SM

ex : $B_s \to J/\psi\, \phi$ (expected BR ~ 10^{-3})



no phase

interference with
$B_s \to \bar{B}_s \to J/\psi\, \phi$
also here
no phase in SM
but φ_d in SUSY
$\Rightarrow$ possible large CP asymmetry for large $(\delta^d_{23})_{RR}$ and large φ_d

CONSTRAINTS on δ's

FROM $\tilde{g}$ or $\tilde{\gamma}$ EXCHANGE (CP conserving processes)

Δm_K	$(\delta^d_{12})_{LL} < 4\cdot 10^{-2}$	$(\delta^d_{12})_{LR} < 4\cdot 10^{-}$
Δm_{B_d}	$(\delta^d_{13})_{LL} < 10^{-1}$	$(\delta^d_{13})_{LR} < 3\cdot 10^{-}$
Δm_D	$(\delta^u_{12})_{LL} < 10^{-1}$	$(\delta^u_{12})_{LR} < 3\cdot 10^{-}$
$b \to s\gamma$	$(\delta^d_{23})_{LL}$ NO BOUND	$(\delta^d_{23})_{LR} < 10^{-2}$
$\mu \to e\gamma$	$(\delta^\ell_{12})_{LL} < 8\cdot 10^{-3}$	$(\delta^\ell_{12})_{LR} < 2\cdot 10^{-}$
$\tau \to \mu\gamma$	$(\delta_{23})_{LL}$ NO BOUND	$(\delta^\ell_{23})_{LR} < 2\cdot 10^{-}$

for $m_{\tilde{q}} = 500$ GeV, $m_{\tilde{\ell}} = 100$ GeV,

$$m_{\tilde{g}}/m_{\tilde{q}} = m_{\tilde{\gamma}}/m_{\tilde{\ell}} = 1$$

bounds scale with $(m_{\tilde{q}}(\mathrm{GeV})/500)$ for $\Delta m_K, \Delta m_B, \Delta m_D$
and with $(m_{\tilde{q}}(\mathrm{GeV})/500)^2$ or $(m_{\tilde{\ell}}(\mathrm{GeV})/100)^2$ for
$b\to s\gamma$, $\mu\to e\gamma$, $\tau\to\mu\gamma$

Gabbiani, A.M.;
Hagelin et al.; Gabbiani, Gabrielli, A.M., Silvestrini; Bagger, Matchev, Zang; Ciuchini et

CP CHALLENGING SUSY

$$\varepsilon \Rightarrow \begin{cases} \sqrt{\mathrm{Im}\left(\delta^d_{12}\right)^2_{LL}} < 3\cdot 10^{-3} \\ \sqrt{\mathrm{Im}\left(\delta^d_{12}\right)^2_{LR}} < 3\cdot 10^{-4} \end{cases}$$

$$\varepsilon' \Rightarrow \begin{cases} \left|\mathrm{Im}\left(\delta^d_{12}\right)_{LL}\right| < 5\cdot 10^{-1} \\ \left|\mathrm{Im}\left(\delta^d_{12}\right)_{LR}\right| < 2\cdot 10^{-5} \end{cases}$$

(bounds scale as $(m_{\tilde{q}}(\mathrm{GeV})/500))^2$

Gabbiani, A.M ;
Hagelin et al. ;
Nir , Seiberg ;
Gabbiani, Gabrielli,
A.M., Silvestrini ;
Bagger, Matchev, Zhang
Ciuchini et al.

$$d^e_n \Longrightarrow \mathrm{Im}\left(\delta^d_{11}\right)_{LR} < 10^{-6}$$

scales as $(m_{\tilde{q}}(\mathrm{GeV})/500)^2$

for $m_{\tilde{q}} = m_{\tilde{g}} = 500$ GeV

$$d^e_e \Longrightarrow \mathrm{Im}\left(\delta^\ell_{11}\right)_{LR} < 10^{-7}$$

for $m_{\tilde{\ell}} = m_{\tilde{\gamma}} = 100$ GeV (it scales as $(m_{\tilde{\ell}}/100\,\mathrm{GeV})$

STEPS TOWARDS A FULL NLO ANALYSIS OF FCNC AND CP̸ IN A GENERAL MSSM

- **1996 GGMS** constraints on δ's
  - without QCD corrections
  - in the Vacuum Insertion Approximation (VIA)
  - only gluino exchange

(for previous works: '89 Gabbiani, A.M. ; '94 Hagelin, Kelley, Tanaka)

- **1997 BAGGER, MATCHEV, ZANG**
  - inclusion of the LO QCD corrections in the $K-\bar{K}$ mixing computation

- **1998 CIUCHINI et al.** $\Delta S = 2$
  - Δm_K and ε_K : inclusion of the NLO anomalous dimensions of the $\Delta S = 2$ effective hamiltonian and replacement of the B-parameters in the VIA with the values obtained in a lattice computation (Allton et al)

● 2001 BECIREVIC et al $\Delta B = 2$

$$\Delta m_d = 2\,\mathrm{Abs}\left[\langle \bar{B}_d | \mathcal{H}_{eff}^{\Delta B=2} | B_d \rangle \right]$$

$$a_{J/\psi K_S} = \sin 2\beta_{eff} \sin \Delta m_d t$$

$$2\beta_{eff} = \mathrm{Arg}\left[\langle \bar{B}_d | \mathcal{H}_{eff}^{\Delta B=2} | B_d \rangle \right]$$

most general Hamiltonian for $\Delta B = 2$ processes

- NLO QCD corrections in the evolution from the scale of new physics down to low energy
- hadronic matrix elements from lattice QCD for operators renormalized consistently with the Wilson coeff. at the NLO

this general result is particularized for the MSSM

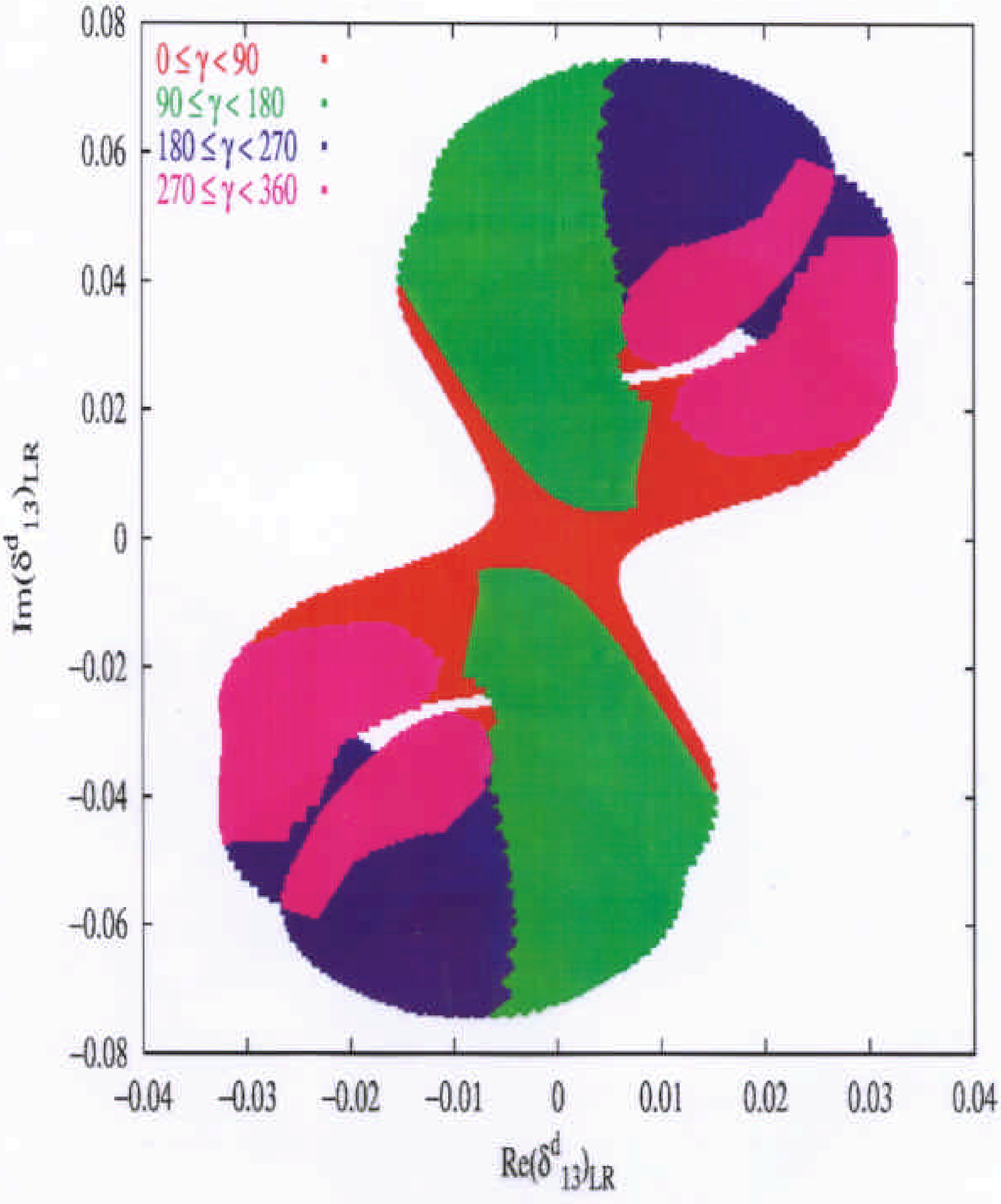
$\Rightarrow$ $\tilde{g}$ exchange, mass insertion approximation

exp. $\sin 2\beta$ $\Longrightarrow$ new stringent constraints on $\mathrm{Im}\,\delta_{13}^d$

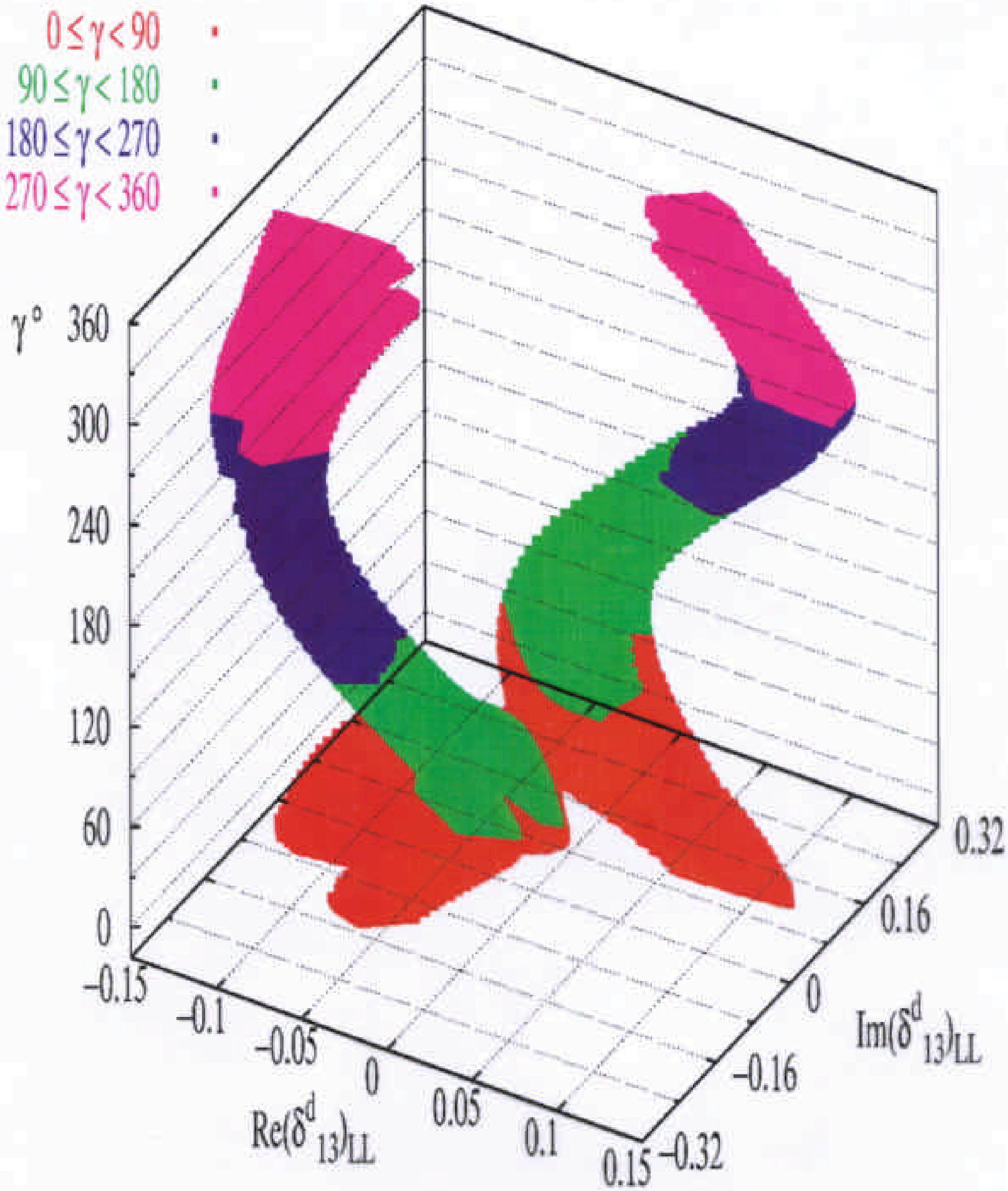
still lacking the full NLO computation: $O(\alpha_s)$ corrections to the matching conditions at the SUSY scale $M_S \sim (m_{\tilde{g}} + m_{\tilde{q}})/2$ which determine the Wilson coeff.

(maybe they are small being of $O(\alpha_s(M_W))$)

BECIREVIC, CIUCHINI, FRANCO, GIMENEZ,
MARTINELLI, A.M., PAPINUTTO, REYES,
SILVESTRINI



BECIREVIC et al.



GIVEN THE ABOVE CONSTRAINTS on the δ's

WHERE (in FCNC and CP $\neq$) TO LOOK FOR SUSY SIGNALS ?

(maximally allowed FCNC and CP $\neq$ SUSY contributions, not typical SUSY predictions)

KAON PHYSICS

ε_K, ε'/ε

↳ large SUSY contributions

enhancement of rare K decays

$K_L \to \pi^0 \nu \bar{\nu}$, $K^+ \to \pi^+ \nu \bar{\nu}$, $K_L \to \pi^0 e^+ e^-$, $K_L \to \mu^+ \mu^-$

B PHYSICS

$b \to s \ell^+ \ell^-$

$b \to d \gamma$ $(B \to \rho \gamma)$

CP $\neq$ B decays

LEPTON PHYSICS

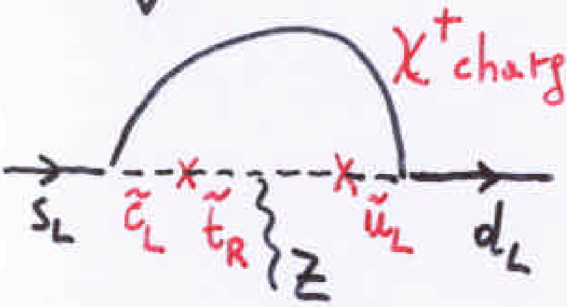
$\mu \to e \gamma$

$\mu \to e e \bar{e}$

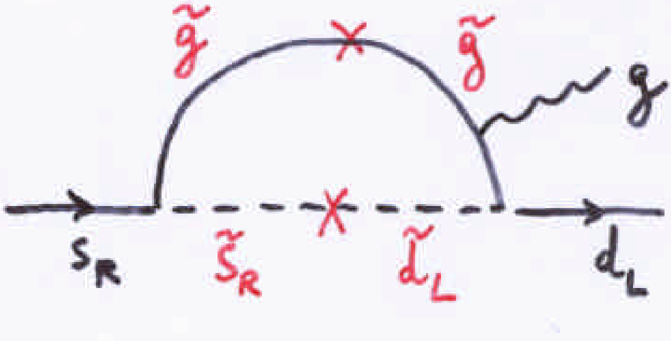
μ-e conversion in nuclei

ε'/ε and RARE K DECAYS

BURAS, COLANGELO, ISIDORI, ROMANINO, SILVESTRIN



s-d-Z



s-d-g

enhancement of $K_L \to \pi^0 e^+ e^-$, $K_L \to \pi^0 \nu\bar{\nu}$, $K^+ \to \pi^+ \nu$

assuming the usual determination of the CKM param

+ no cancellations among different SUSY effects in ε'/ε

$\Downarrow$

SM

$BR(K_L \to \pi^0 e^+ e^-)_{dir} \lesssim 2 \cdot 10^{-11}$ $(7 \cdot 10^{-1}$

$BR(K_L \to \pi^0 \nu\bar{\nu}) \lesssim 1.2 \cdot 10^{-10}$ $(3 \cdot 10^{-1}$

$BR(K^+ \to \pi^+ \nu\bar{\nu}) \lesssim 1.7 \cdot 10^{-10}$ $(0.8 \cdot 10$

(larger values possible but rather unlikely)

correlation "$\sin 2\beta$" from K and B decays NIR, WORAH

A_{FB} for $B \to X_s \ell^+\ell^-$

LUNGHI, A.M., SCIMEMI, SILVESTRINI

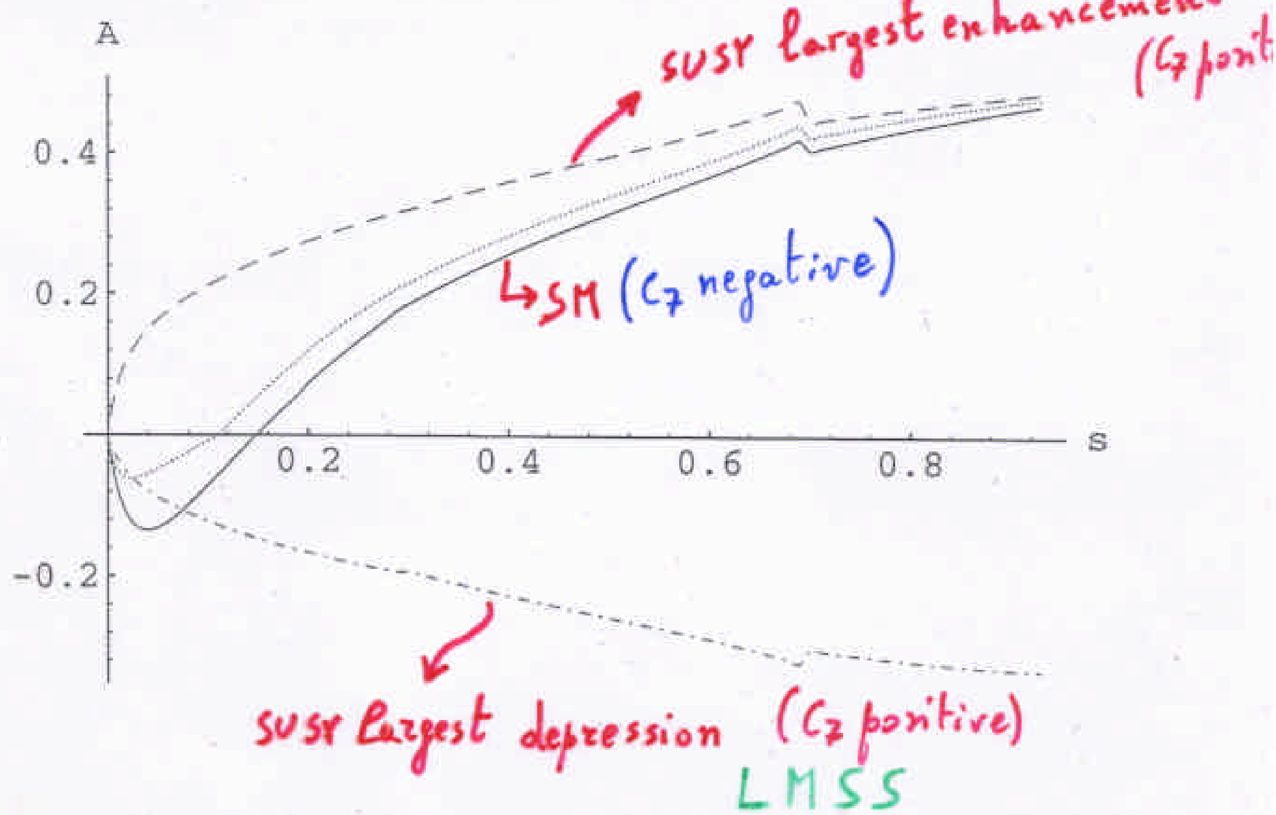


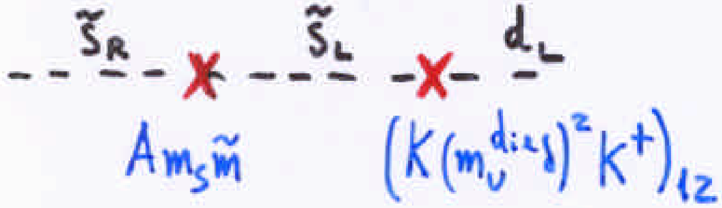
Figure 6: *Forward–Backward asymmetry (A_{FB}) for the decay $B \to X_s \ell^+ \ell^-$. The solid line corresponds to the SM expectation; the dashed and dotted-dashed line corresponds to the SUSY best enhancement ($C_7^{eff} = 0.445, C_9^{MI} = 1.2, C_{10}^{MI} = -2.1$) and depression ($C_7^{eff} = .250, C_9^{MI} = -0.5, C_{10}^{MI} = 6.6$); the dotted line is the maximum enhancement obtained without changing the sign of C_7 ($C_7^{eff} = -0.250, C_9^{MI} = 0.5, C_{10}^{MI} = 1.1$).*

$\varepsilon'/\varepsilon \;\longrightarrow\; \text{Im}\left(\delta^d_{12}\right)_{LR} \sim 10^{-5}$

$\varepsilon \;\longrightarrow\; \text{Im}\left(\delta^d_{12}\right)_{LL} \sim 3 \cdot 10^{-3}$

easy to obtain with SUSY phases of $O(10^{-1})$

in MSSM with flavor universality:



$\longrightarrow$ completely negligible

Gabrielli, Giudice

$\hookrightarrow$ SUSY CONTRIBUTION TO ε'/ε IS VERY TINY

($\rightarrow$ MSSM WITH FLAVOR UNIV. $\not{CP}$ OF SUPERWEAK KI

THIS STATEMENT DOES **NOT** APPLY TO

"REASONABLE" SUSY MODELS WITH NEW FLAVOR STRUC

Ex: $W \supset Y_D^{ij}(T)\, Q^i D^j H_D$ (T moduli fields)

$\hookrightarrow$ Yukawa couplings: $Y_D^{ij}(\langle T \rangle)$

trilinear scalar couplings: $\tilde{d}_L \tilde{d}_R^* H$: $\langle F_T \rangle$

$\hookrightarrow$ SUSY BREAKIN

$$\mathcal{L}_{trilinear} \supset \frac{\partial Y_D^{ij}}{\partial T} \langle F_T \rangle\, \tilde{Q}^i \tilde{D}^j H_D$$

A.M., Murayama

$$M_d \propto \begin{pmatrix} m_d & m_s \sin\theta_c \\ & m_s \end{pmatrix}$$

$(\delta_{12})_{LR}$

$$M^2_{\tilde{d}_L \tilde{d}_R} \propto \begin{pmatrix} a\, m_d & b\, m_s \sin\theta_c \\ & c\, m_s \end{pmatrix}$$

a, b, c constants of $O(1)$ $\Longrightarrow$ unless $a = b = c$ exactly, M_d and $M^2_{\tilde{d}_L \tilde{d}_R}$ are

NOT SIMULTANEOUSLY DIAGONALIZABLE

$\tilde{d}_L \; \times \; \tilde{s}_R$

$$(\delta^d_{12})_{LR} \simeq \frac{\overset{\nearrow \langle F_T \rangle}{\tilde{m}}\, m_s \sin\theta_c}{m^2_{\tilde{q}}} =$$

$$= 2 \times 10^{-5} \left(\frac{m_s(M_{PL})}{50\,\mathrm{MeV}}\right) \left(\frac{\tilde{m}}{m_{\tilde{q}}}\right) \left(\frac{500\,\mathrm{GeV}}{m_{\tilde{q}}}\right)$$

A.M., Murayama; Babu, Dutta, Mohapat
Khalil, Kobayashi, Vives

possibility of achieving it through double mass insertion $\tilde{d}_L \times \tilde{s}_L \times \tilde{s}$

Baek, Ko

CONCLUSIONS

- **Q1 :** IF SUSY BREAKING IS FLAVOR BLIND

  $\Rightarrow$ STILL HOPE TO FIND SUSY SIGNALS IN FCNC and/or CP $\not=$ PROCESSES ?

- **A1 :** Yes, if SUSY CP phases are large (EDM's)

  YES, if SUSY SEE-SAW (not only large LFV but also large $b \to s$ in SUSY GUT's)

- **Q2 :** IF SUSY BREAKING INTRODUCES NEW SOURCES OF FLAVOR (i.e. $M_{\text{sfermion}} \nparallel M_{\text{fermion}}$)

  $\Rightarrow$ HOW SEVERE IS THE FLAVOR PROBLEM WHERE TO LOOK FOR SUSY SIGNALS ?

- **A2 :** quite severe $\Rightarrow$ FAMILY SYMMETRIES ?

  in addition to EDM's, LFV

  CP$\not=$ in B physics, rare B and K decays ($b \to s \ell^+ \ell^-$) $K \to \pi \nu \bar{\nu}$