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SuperIso and new constraints from B physics

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Outline

Introduction

Theoretical framework

Effective Hamiltonian Isospin Asymmetry Supersymmetric contributions

SuperIso v1.0

Experimental limits and data

New constraints from Isospin Asymmetry

Conclusion



Introduction •	Theoretical framework	SuperIso 000	Experimental limits and data	Results 00	Conclusion 0

- $b \longrightarrow s\gamma$ transitions: very sensitive to new physics
 - forbidden at the tree level in SM and can only be induced via loop diagrams,
 - SM contributions are vanishlingly small,
- branching ratios have been extensively used to constrain SUSY parameter space
- Study another observable: isospin asymmetry
 - already measured by BELLE and BABAR
 - calculable with the publicly available code Superlso

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Effective Hamiltoni	an				

Effective Hamiltonian

The idea of $B \longrightarrow X_s \gamma$ decay begins with introducing an effective Hamiltonian:

$$\mathcal{H}_{eff} = -rac{4G_F}{\sqrt{2}}V_{ts}^*V_{tb}\sum_{i=1}^8C_i(\mu)O_i(\mu)$$

$$O_{1} = (\bar{s}_{L}\gamma_{\mu}T^{a}c_{L})(\bar{c}_{L}\gamma^{\mu}T^{a}b_{L}) \qquad O_{2} = (\bar{s}_{L}\gamma_{\mu}c_{L})(\bar{c}_{L}\gamma^{\mu}b_{L})$$

$$O_{3} = (\bar{s}_{L}\gamma_{\mu}b_{L})\sum_{q}(\bar{q}\gamma^{\mu}q) \qquad O_{4} = (\bar{s}_{L}\gamma_{\mu}T^{a}b_{L})\sum_{q}(\bar{q}\gamma^{\mu}T^{a}q)$$

$$O_{5} = (\bar{s}_{L}\gamma_{\mu_{1}}\gamma_{\mu_{2}}\gamma_{\mu_{3}}b_{L})\sum_{q}(\bar{q}\gamma^{\mu_{1}}\gamma^{\mu_{2}}\gamma^{\mu_{3}}q)$$

$$O_{6} = (\bar{s}_{L}\gamma_{\mu_{1}}\gamma_{\mu_{2}}\gamma_{\mu_{3}}T^{a}b_{L})\sum_{q}(\bar{q}\gamma^{\mu_{1}}\gamma^{\mu_{2}}\gamma^{\mu_{3}}T^{a}q)$$

$$O_{7} = \frac{e}{16\pi^{2}}m_{b}(\bar{s}_{L}\sigma^{\mu\nu}b_{R})F_{\mu\nu} \qquad O_{8} = \frac{g}{16\pi^{2}}m_{b}(\bar{s}_{L}\sigma^{\mu\nu}T^{a}b_{R})G_{\mu\nu}^{a}$$

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Effective Hamiltonian								

Wilson Coefficients

$$C_i^{eff}(\mu) = C_i^{(0)eff}(\mu) + \frac{\alpha_s(\mu)}{4\pi}C_i^{(1)eff}(\mu) + \cdots$$

The effective coefficients evolve according to their RGE:

$$\mu \frac{d}{d\mu} C_i^{\text{eff}}(\mu) = C_j^{\text{eff}}(\mu) \gamma_{ji}^{\text{eff}}(\mu)$$

driven by the anomalous dimension matrix $\hat{\gamma}^{eff}(\mu)$:

$$\hat{\gamma}^{\text{eff}}(\mu) = \frac{\alpha_s(\mu)}{4\pi} \hat{\gamma}^{(0)\text{eff}} + \frac{\alpha_s^2(\mu)}{(4\pi)^2} \hat{\gamma}^{(1)\text{eff}} + \cdots$$

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Isospin Asymmetry	,				

Isospin Asymmetry

$$\Delta_{0-} \equiv \frac{\Gamma(\bar{B}^0 \to \bar{K}^{*0}\gamma) - \Gamma(B^- \to K^{*-}\gamma)}{\Gamma(\bar{B}^0 \to \bar{K}^{*0}\gamma) + \Gamma(B^- \to K^{*-}\gamma)}$$
$$\Delta_{0-} = \operatorname{Re}(b_d - b_u).$$
$$b_q = \frac{12\pi^2 f_B Q_q}{m_b T_1^{B \to K^*} a_7^c} \left(\frac{f_{K^*}^{\perp}}{m_b} K_1 + \frac{f_{K^*} m_{K^*}}{6\lambda_B m_B} K_2\right)$$
$$= C_7 + \frac{\alpha_s(\mu)C_F}{4\pi} \left(C_1(\mu)G_1(s_p) + C_8(\mu)G_8\right) + \frac{\alpha_s(\mu_h)C_F}{4\pi} \left(C_1(\mu_h)H_1(s_p) + C_8(\mu_h)H_8\right)$$

In the Standard Model: $\Delta_{0-}\simeq 8\%$

Kagan and Neubert, Phys. Lett. B 539, 227 (2002) Bosch and Buchalla, Nucl. Phys. B 621, 459 (2002)

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Isospin Asymmetry					

Contribution to Isospin Asymmetry

b $O_3 O_6$ S γ \overline{q} \overline{q}



QCD penguin operators



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Supersymmetric co	ntributions				

Supersymmetric contributions MSSM with minimal flavor violation (MFV) ↔ no more flavor/CP violation than in SM



Calculation of the coefficients at $\mu = M_W$:

$$C_{i}(\mu) = C_{i}^{W^{\pm}}(\mu) + C_{i}^{H^{\pm}}(\mu) + C_{i}^{\chi^{\pm}}(\mu)$$

Gómez et al. Phys. Rev. D74, 015015 (2006) Degrassi et al. JHEP 12, 009 (2000) Ciuchini et al. Nucl. Phys. B 534, 3 (1998) Ciuchini et al. Nucl. Phys. B 527, 21 (1998)

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Theoretical framework	SuperIso ●00	Experimental limits and data	Results 00	Conclusion 0

A public C–program for calculating isospin asymmetry of $B\to K^*\gamma$ in supersymmetry.

- calculation of isospin asymmetry and inclusive branching ratio,
- automatic calculation in mSUGRA, AMSB and GMSB scenarios,
- compatible with the SUSY Les Houches Accord Format,
- modular program, with a well-defined structure.

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SuperIso

Theoretical framework	SuperIso ○○●	Experimental limits and data	Results 00	Conclusion 0

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Can be downloaded from:
http://www3.tsl.uu.se/~nazila/superiso/
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Manual:

F. Mahmoudi, arXiv:0710.2067 to appear in Comp. Phys. Comm.

For more information:

Ahmady & Mahmoudi, Phys. Rev. D75 (2007) F. Mahmoudi, arXiv:0710.4501, submitted to JHEP

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Experimental data

BABAR

$$\Delta_{0-} = -0.006 \pm 0.058(\textit{stat}) \pm 0.009(\textit{syst}) \pm 0.024(\textit{R}^{+/0})$$

Aubert et al. (BABAR Collaboration) Phys. Rev. D72 (2005)

$\frac{\text{BELLE}}{\Delta_{0+}} = +0.012 \pm 0.044(\text{stat}) \pm 0.026(\text{syst})$

Nakao et al. (BELLE Collaboration) Phys. Rev. D69 (2004)

Allowed Region: $-0.018 < \Delta_{0-} < 0.093$

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Experimental limits

Lower bounds on sparticle masses in GeV:

Particle	h ⁰	χ_1^0	Ĩ _R	$\tilde{\nu}_{e,\mu}$	χ_1^{\pm}	\tilde{t}_1	ĝ	\tilde{b}_1	$\tilde{\tau}_1$	<i>q̃</i> _R
Lower bound	111	46	88	43.7	67.7	92.6	195	89	81.9	250

Yao et al. J. Phys. G33 (2006)

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Results: mSUGRA



Ahmady & Mahmoudi, Phys. Rev. D75 (2007)

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Results: mSUGRA



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Ahmady & Mahmoudi, Phys. Rev. D75 (2007)

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Results: mSUGRA



F. Mahmoudi, arXiv:0710.4501

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Results: mSUGRA



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Results: mSUGRA



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Results: NUHM



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Results: NUHM



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Results: AMSB



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Theoretical framework	SuperIso 000	Experimental limits and data 000000●0	Results 00	Conclusion 0

Results: AMSB



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Theoretical framework	SuperIso 000	Experimental limits and data 0000000●	Results 00	Conclusion 0

Results: GMSB



F. Mahmoudi, arXiv:0710.4501

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Theoretical framework	SuperIso 000	Experimental limits and data	Results ●0	Conclusion 0

Results



$$\mathcal{B}(B_s
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Results:

mSUGRA



F. Mahmoudi, arXiv:0710.4501



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Results:

mSUGRA

AMSB

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- We can obtain new constraints (new contours) using the Isospin asymmetry
- Very tight constraints on the studied parameter spaces, complementary or even more restrictive than the inclusive branching ratio
- Can be applied to other scenarios
- Isospin asymmetry seems to be an important observable in the precision test of the SM and in constraining new physics parameters

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