

Uplifted Supersymmetry

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with Bogdan Dobrescu
(under construction)



Plan

A new phase of an old model?

- MSSM review
- Type-II and type-III 2HDM's
- The MSSM near $\tan \beta = \infty$
- Loop generated masses
- Phenomenology
- Conclusions

MSSM in a slide

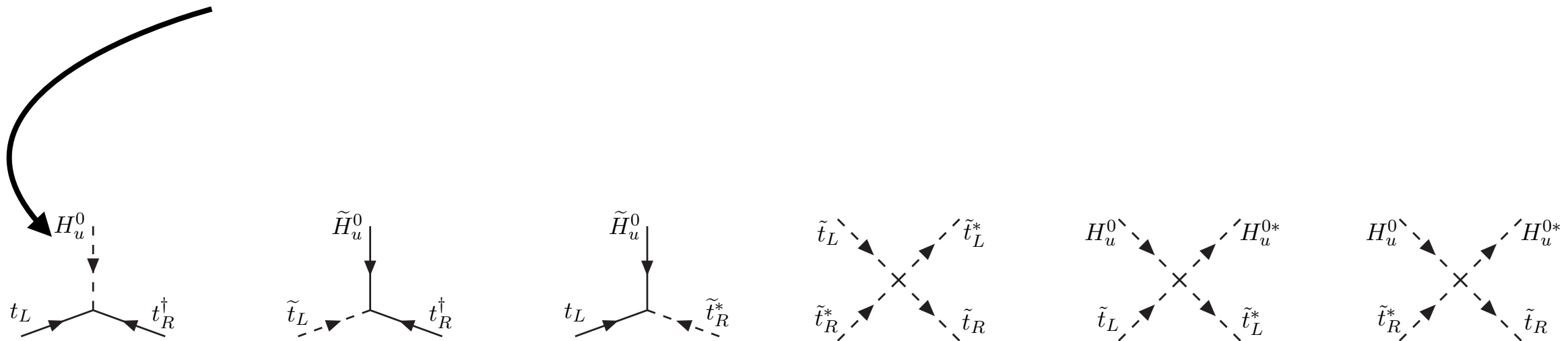
- The “minimal” supersymmetric version of the SM
- Partners of opposite spin
- Anomalies require two Higgs (Higgsino) doublets
- Holomorphy forces a Type-II 2HDM

$$W = y_u \hat{u}^c \hat{H}_u \hat{Q} - y_d \hat{d}^c \hat{H}_d \hat{Q} - y_\ell \hat{e}^c \hat{H}_d \hat{L} + \mu \hat{H}_u \hat{H}_d$$

MSSM in a slide

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2HDM

At tree level can define $\tan \beta \equiv \frac{v_u}{v_d}$

The MSSM Yukawa couplings

$$y_u^{MSSM} = \frac{y_u^{SM}}{\sin \beta}$$

$$y_d^{MSSM} = \frac{y_d^{SM}}{\cos \beta}$$

Usually perturbativity ($y_b \lesssim 1$) places a constraint on y_b :

$$\tan \beta \lesssim 50 - 60$$

2HDM

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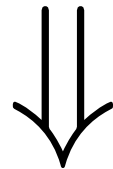
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I wish to consider case of $\tan \beta \approx \infty$

Only up-type Higgs acquires a vev



Only u,c,t massive?

$$W = y_u \hat{u}^c \hat{H}_u \hat{Q} - y_d \hat{d}^c \hat{H}_d \hat{Q} - y_\ell \hat{e}^c \hat{H}_d \hat{L} + \mu \hat{H}_u \hat{H}_d$$

All chiral symmetries explicitly broken by superpotential

Once SUSY is broken can generate new “wrong-type” Yukawas

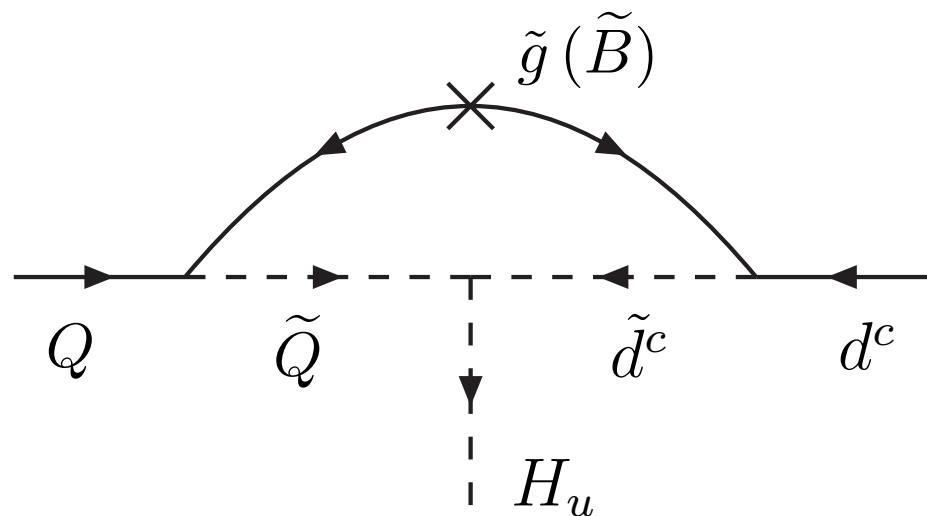
$$-y'_d d^c H_u^\dagger Q - y'_\ell e^c H_u^\dagger L + \text{H.c.}$$

MSSM becomes Type-III 2HDM

Loop generation of masses (a short domino)

[Dobrescu and PjF]

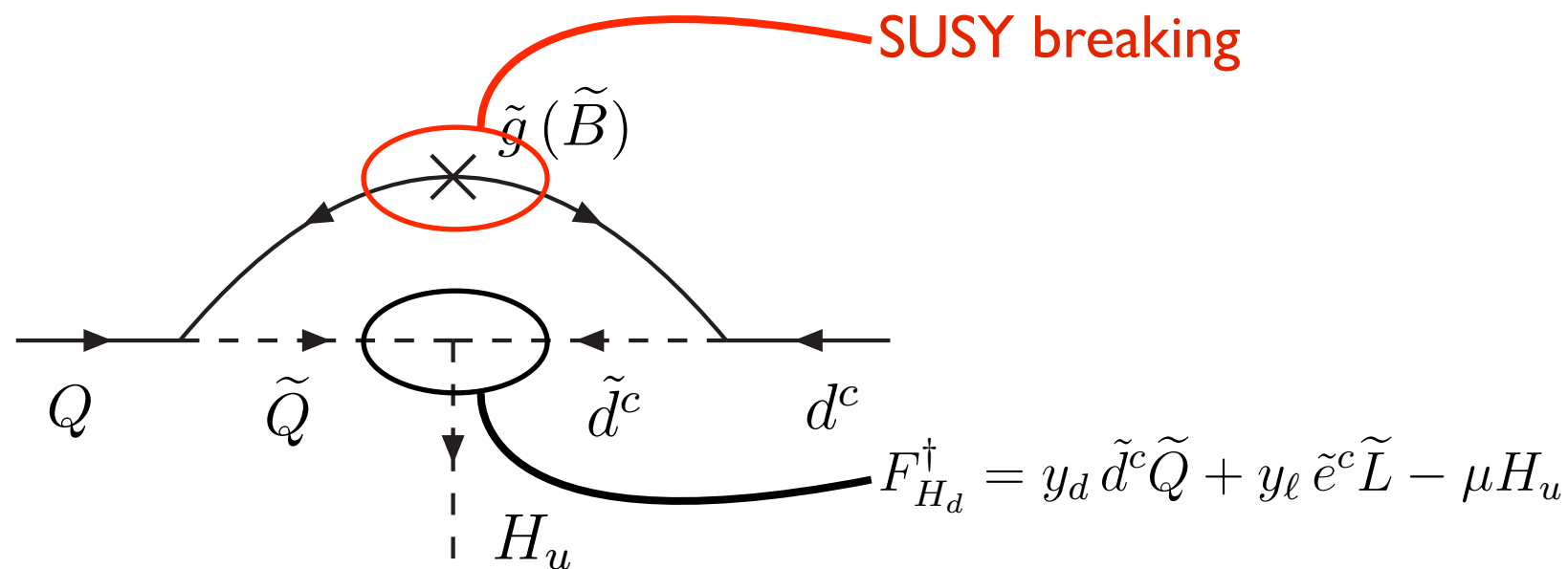
Wrong type Higgs couplings



$$\tilde{y}_d = \frac{\alpha_3}{2\pi} \frac{N_c^2 - 1}{2N_c} y_d \mu^* M_{\tilde{g}}^* I(M_{\tilde{Q}_3}, M_{\tilde{g}}, M_{\tilde{u}_3})$$

$$I(m_1, m_2, m_3) = \frac{m_1^2 m_2^2 \log(m_1^2/m_2^2) + m_2^2 m_3^2 \log(m_2^2/m_3^2) + m_3^2 m_1^2 \log(m_3^2/m_1^2)}{(m_1^2 - m_2^2)(m_2^2 - m_3^2)(m_1^2 - m_3^2)} .$$

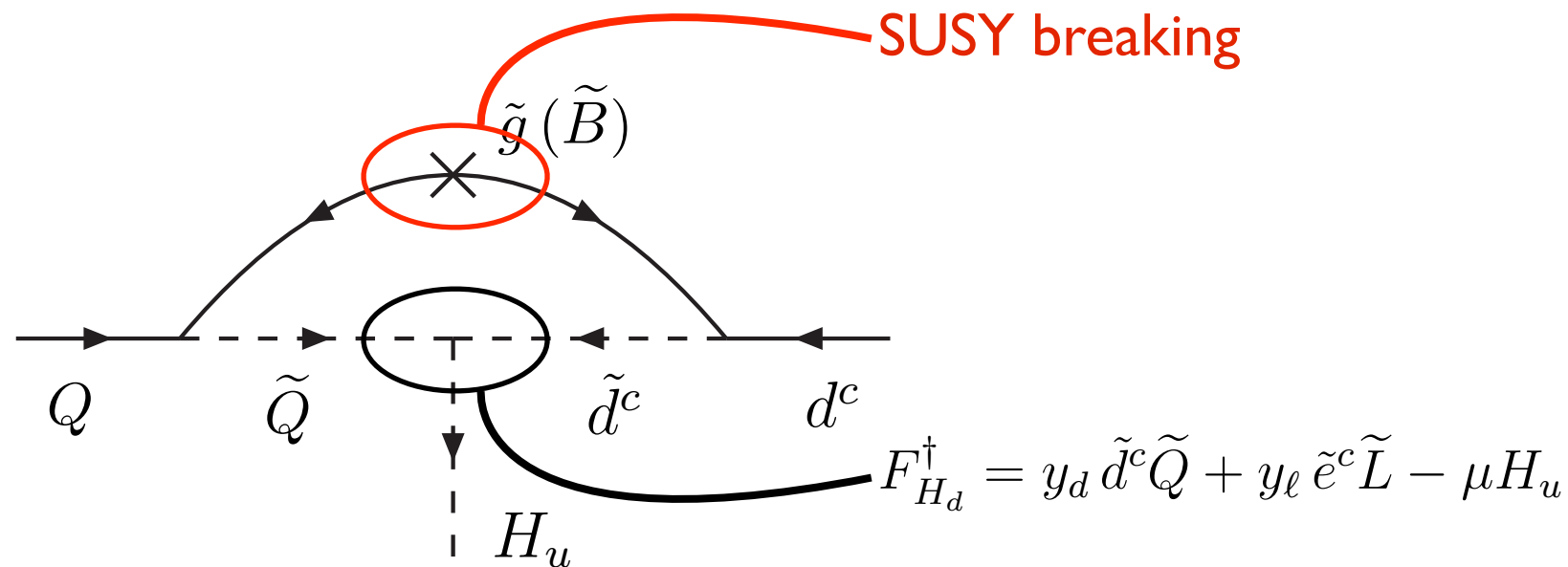
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Wrong type Higgs couplings



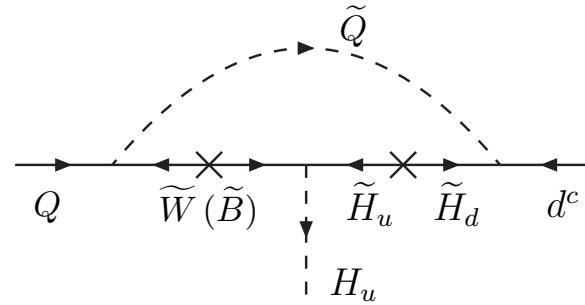
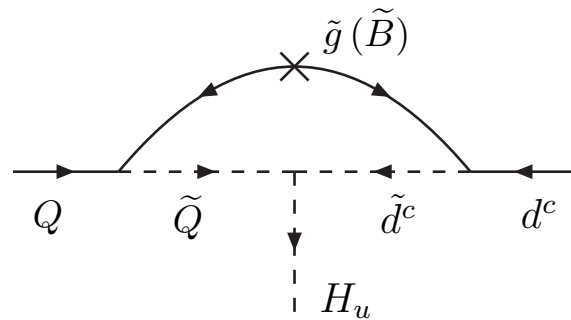
Effective Yukawa

Lagrangian parameter

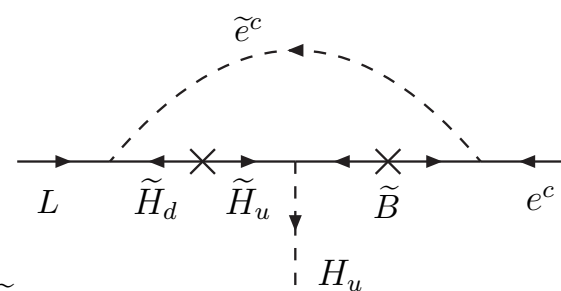
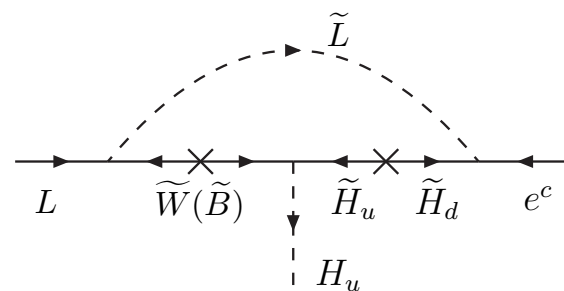
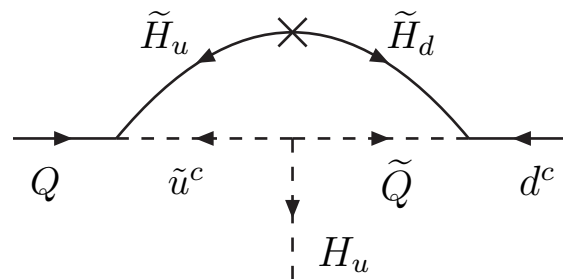
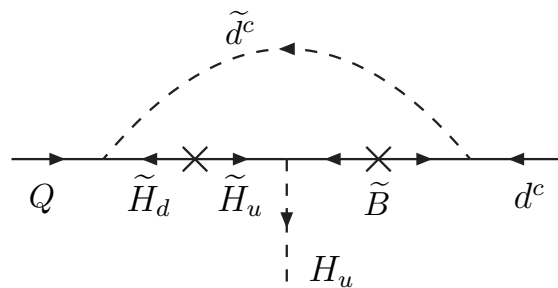
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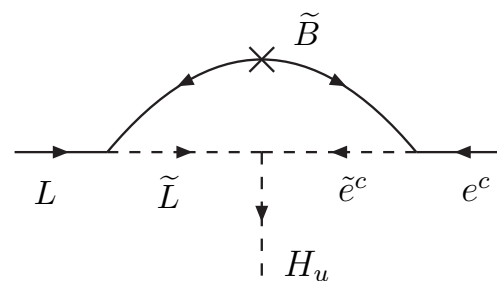
Wrong type Higgs couplings



Down-type quarks



Leptons



Loop corrections to $\tan \beta$

At tree level really at infinity (R-symmetry forbids bmu-term)

$$V_H = (|\mu|^2 + m_{H_u}^2) |H_u|^2 + (|\mu|^2 + m_{H_d}^2) |H_d|^2 + \frac{1}{8} (g^2 + g'^2) (|H_u|^2 - |H_d|^2)^2$$

At tree level

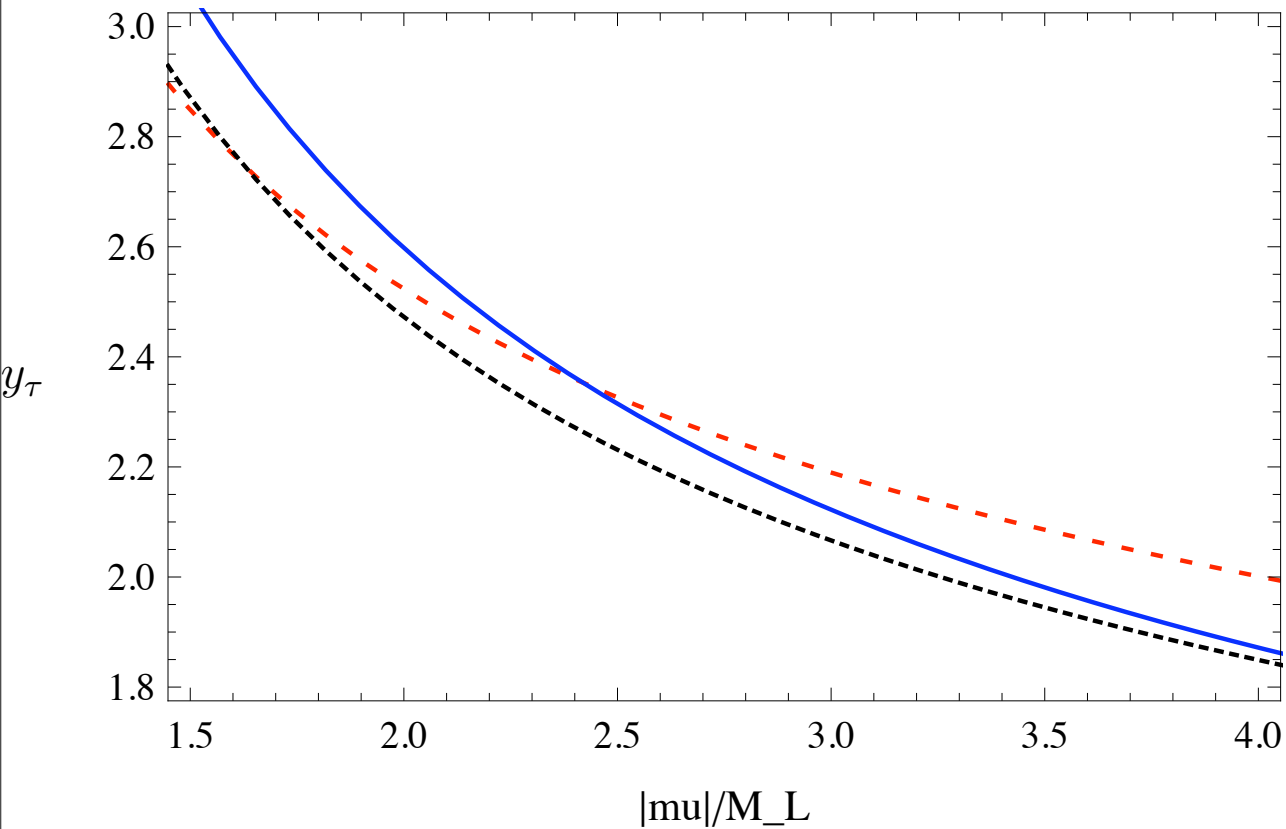
$$M_{h^0}^2 = M_Z^2$$

$$M_{H^0}^2 = M_{A^0}^2 = M_{H^\pm}^2 = |\mu|^2 + m_{H_d}^2$$

Once SUSY is broken bmu generated at one loop

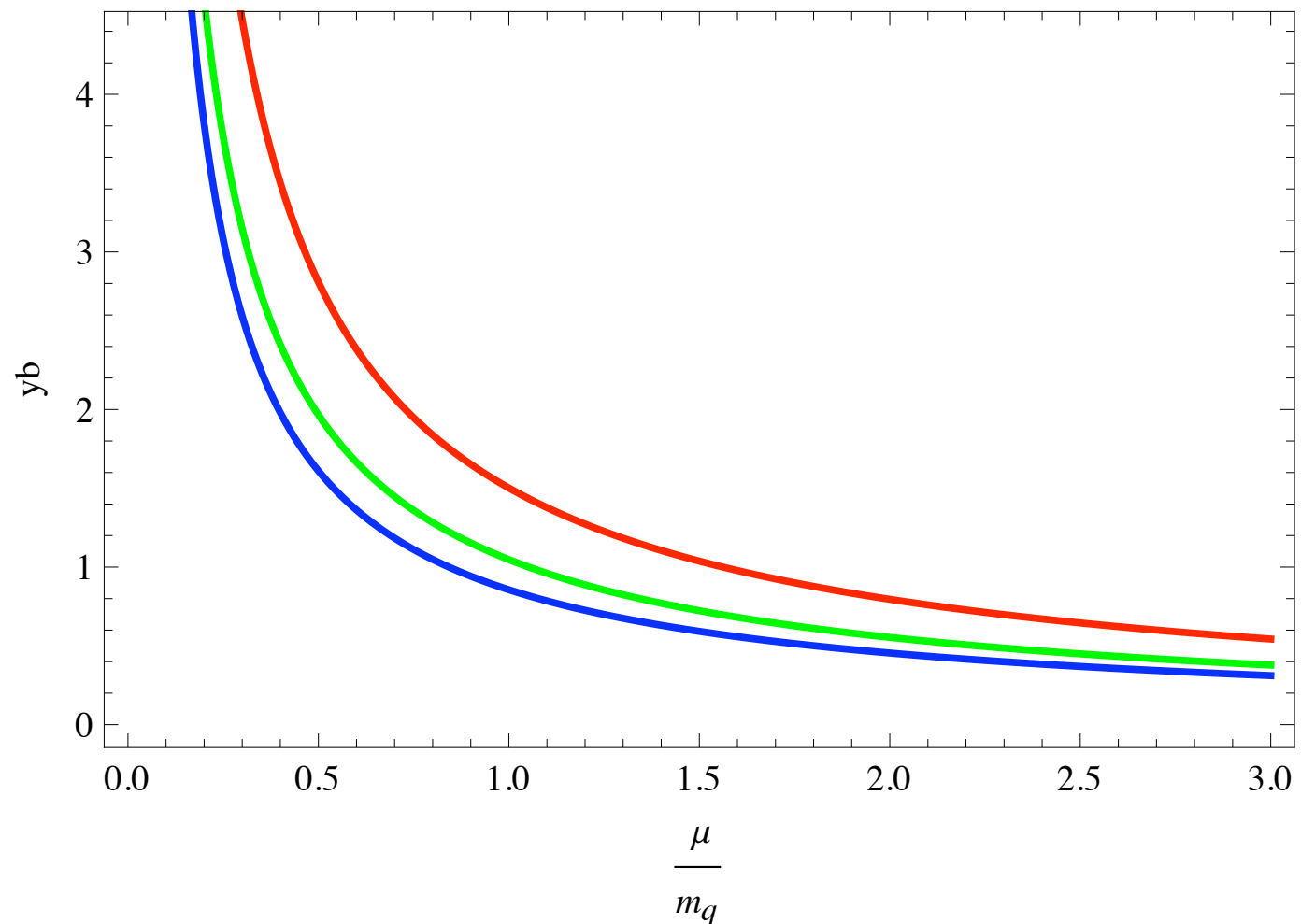
$$\tan \beta \sim 10^2 - 10^3$$

Yukawa couplings



Depends on several
parameters:
Tau-bino/slepton = 0.4,
0.7, 1

Depends on several
parameters:
Bottom-gluino/squark
= 2, 1, 0.5



Phenomenology

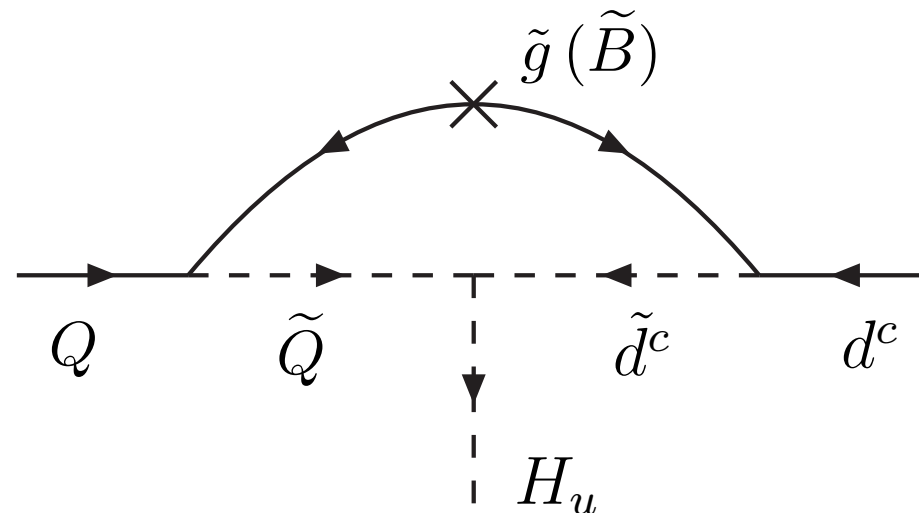
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$$y_\tau > y_b$$

Heavy Higgses approximately degenerate

Increased branching ratio to fermions

In particular decays now to **tau's not b's**



Higgs couplings to down-type and leptons are momentum dependent

Conclusions

- New phase of an old model
- Up-type Higgs responsible for all masses in MSSM--
Uplifted MSMS
- Tan beta not always a good variable
- Yukawas can be generated at the loop level within
MSSM, no new field content
- Tau-heavy-higgs coupling increased
- Easier (?) to find the heavy higgses

