From Flavour to SUSY Flavour Models

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SUSY10

Based on work in progress with Stefan Antusch, Lorenzo Calibbi and Martin Spinrath

Outline

1. Motivation
2. Defining a SUSY Flavour Model
3. Testing a SUSY Flavour Model
4. Summary

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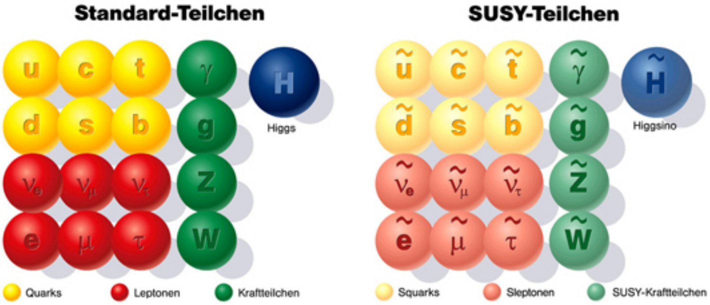
What we want to describe



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Class of Models

- Symmetries:

$$SU(5) \times G_{\text{family}}$$

- Matter fields:

$$F \sim (\bar{5}, 3) \quad T_{1,2,3} \sim (10, 1) \quad N_{1,2} \sim (1, 1)$$

- Flavon fields:

$$\phi_i \sim (1, 3)$$

- G_{family} broken by vevs in the directions [Antusch, King, Spinrath '10]

$$\phi_1 \sim \begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}, \phi_2 \sim \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, \tilde{\phi}_2 \sim \begin{pmatrix} 0 \\ \mathrm{i} \\ w \end{pmatrix}, \phi_3 \sim \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

- Features: Tribimaximal mixing, CP violation with $\alpha = 90^\circ$

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Matrix Textures

- Y_u, M_N diagonal

- $$Y_d = \begin{pmatrix} 0 & \epsilon_1 & -\epsilon_1 \\ \epsilon_2 & \epsilon_2 + \mathrm{i}\,\tilde{\epsilon}_2 & \epsilon_2 + w\,\tilde{\epsilon}_2 \\ 0 & 0 & \epsilon_3 \end{pmatrix},$$

$$Y_e^T = \begin{pmatrix} 0 & c_1\,\epsilon_1 & -c_1\,\epsilon_1 \\ c_2\,\epsilon_2 & c_2\,\epsilon_2 + \mathrm{i}\,\tilde{c}_2\,\tilde{\epsilon}_2 & c_2\,\epsilon_2 + w\,\tilde{c}_2\,\tilde{\epsilon}_2 \\ 0 & 0 & c_3\,\epsilon_3 \end{pmatrix}$$

with $c_1 = c_2 = c_3 = -\frac{3}{2}, \quad \tilde{c}_2 = 6$ [Antusch, Spinrath '09]

- Kähler potential

$$K = F^\dagger F + T_i^\dagger T_i + \frac{\phi_i^\dagger \phi_i}{M^2} F^\dagger F + \frac{\phi_i^\dagger \phi_i}{M^2} T_i^\dagger T_i$$

- Using hierarchy $\epsilon_3 \sim y_b \gg y_{d,s} \sim \epsilon_i$:

$$\tilde{K}_{FF^\dagger} \approx \mathrm{diag}(1, 1, 1 + \zeta^2)$$

with $\zeta^2 \sim \frac{\phi_3^\dagger \phi_3}{M^2}$

[Antusch, King, Malinsky '07] [Antusch, Calibbi, V.M., Spinrath in preparation]

Canonical Normalisation

Rescale superfields $F \to \mathrm{diag}(1, 1, 1 - \frac{1}{2}\zeta^2) F$

$$Y_d = \begin{pmatrix} 0 & \epsilon_1 & -\epsilon_1 (1 - \frac{1}{2}\zeta^2) \\ \epsilon_2 & \epsilon_2 + \mathrm{i}\,\tilde{\epsilon}_2 & (\epsilon_2 + w\,\tilde{\epsilon}_2)\,(1 - \frac{1}{2}\zeta^2) \\ 0 & 0 & \epsilon_3\,(1 - \frac{1}{2}\zeta^2) \end{pmatrix}$$

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Parameterisation for Threshold Corrections

Simple formulae (see e.g. [Hall, Rattazzi, Sarid '94] , [Blazek, Raby, Pokorski '95]):

$$
\begin{aligned}
y^{SM}_{e,\mu,\tau} &\approx (1 + \epsilon_l \tan\beta)\; y^{MSSM}_{e,\mu,\tau} \cos\beta \\
y^{SM}_{d,s} &\approx (1 + \epsilon_q \tan\beta)\; y^{MSSM}_{d,s} \cos\beta \\
y^{SM}_{b} &\approx (1 + (\epsilon_q + \epsilon_A) \tan\beta)\; y^{MSSM}_{b} \cos\beta
\end{aligned}
$$

$$
\theta^{SM}_{i3} \approx \frac{1 + \epsilon_q \tan\beta}{1 + (\epsilon_q + \epsilon_A)\tan\beta}\; \theta^{MSSM}_{i3}
$$

$$
\begin{aligned}
\theta^{SM}_{12} &\approx \theta^{MSSM}_{12} \\
\delta^{SM}_{CKM} &\approx \delta^{MSSM}_{CKM}
\end{aligned}
$$

[Antusch, Calibbi, V.M., Spinrath in preparation]

Application to our Class of Models

GUT ratios and θ_{13} require

- $\frac{3}{2} \stackrel{!}{=} \frac{y_\tau}{y_b} = \frac{1+(\epsilon_q+\epsilon_A)\tan\beta}{1+\epsilon_l\tan\beta}\, 1.25$

  $\Rightarrow (\epsilon_q + \epsilon_A - \epsilon_l)\tan\beta = 0.20$

- $6 \stackrel{!}{\approx} \frac{y_\mu}{y_s} = \frac{1+\epsilon_q\tan\beta}{1+\epsilon_l\tan\beta}\, 4.29$

  $\Rightarrow (\epsilon_q - \epsilon_l)\tan\beta = 0.40$

- $(1 - \frac{1}{2}\zeta^2)\, 3.7 \stackrel{!}{=} \theta_{13} \cdot 10^3 \approx (1 + \epsilon_A \tan\beta)\, 3.2$

  $\Rightarrow \epsilon_A \tan\beta + \frac{1}{2}\zeta^2 = 0.14$

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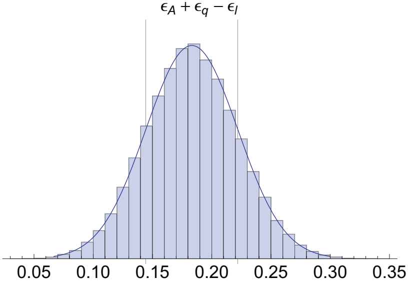

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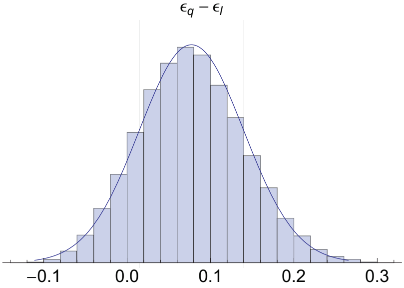

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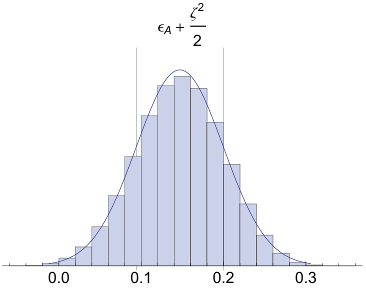

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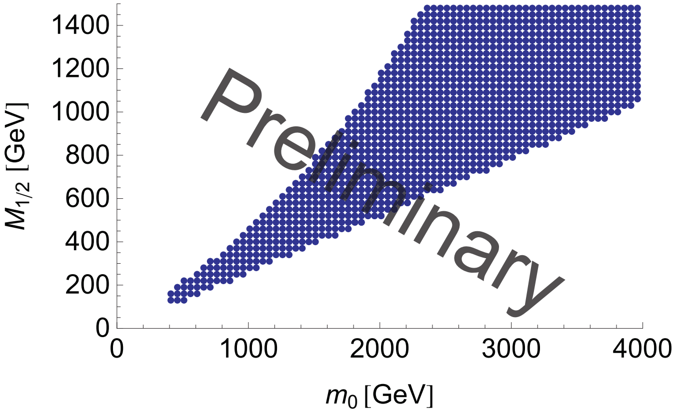
Constraining the Spectrum

Taking $\frac{\zeta^2}{2} = 0.04$ and $\frac{A_0}{m_0} = 3.25$

$\frac{y_\tau}{y_b}$	✓
θ_{13}	



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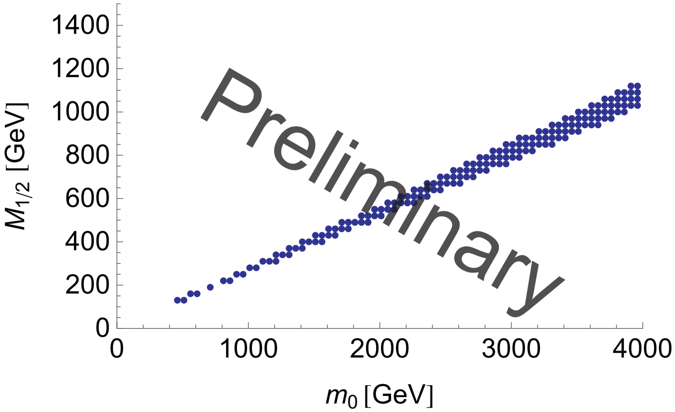

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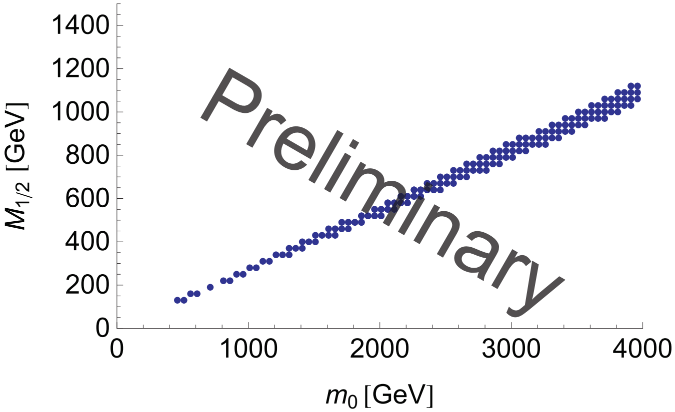

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Predictions for SUSY Flavour Structure

- Typically $F_\phi = \mathcal{O}(1) m_{3/2} \langle \phi \rangle$
- SUGRA (+ sequestering) results in

$$\tilde{m}^2 = m_{3/2}^2 \tilde{K} - F_{\bar{n}} \, F_m \, \partial_{\bar{n}} \, \partial_m \, \tilde{K}$$
$$A = A_0 \, Y + F_m \, \partial_m \, Y$$

- In our class of models

$$m_{\tilde{F}}^2 = m_0^2 \, \mathrm{diag}(1, 1, 1 - x^2 \, \zeta^2)$$
$$A_d = A_0 \begin{pmatrix} 0 & x_1 \, \epsilon_1 & -x_1 \, \epsilon_1 \, (1 - \frac{1}{2}\zeta^2) \\ x_2 \, \epsilon_2 & x_2 \, \epsilon_2 + \mathrm{i} \, \tilde{x}_2 \, \tilde{\epsilon}_2 & (x_2 \, \epsilon_2 + \tilde{x}_2 \, w \, \tilde{\epsilon}_2) \, (1 - \frac{1}{2}\zeta^2) \\ 0 & 0 & x_3 \, \epsilon_3 \, (1 - \frac{1}{2}\zeta^2) \end{pmatrix}$$
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Summary

- Extend flavour models to SUSY/SUGRA flavour models
- Keep track of all effects!
  - canonical normalisation
  - SUSY threshold corrections
  - deviations from CMSSM
- Tests for SUSY/SUGRA flavour model
  - SUSY spectrum
  - flavour violation
  - CP violation

End of the Talk

Thanks for your attention!