Family symmetry flavour problem

Ivo de Medeiros Varzielas

Rudolph Peierls Centre for Theoretical Physics
University of Oxford

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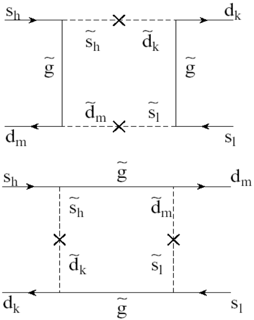
Outline

FCNCs in SUSY



δ parametrisation

$$\Delta_{ij} : - - \text{X} - -$$

$$\Delta_{ij} \equiv (VM^2V^\dagger)_{ij}$$

$$\delta_{ij} \equiv \frac{\Delta_{ij}}{\langle m \rangle^2}$$

δ parameter

δ_{12} example

$$\delta_{12} = \frac{V_{11}\Delta m^2_{\tilde{1}} V^*_{21} + V_{12}\Delta m^2_{\tilde{2}} V^*_{22} + V_{13}\Delta m^2_{\tilde{3}} V^*_{23}}{\langle m_{\tilde{f}} \rangle^2}$$

- V: unitary matrix
- $\langle m \rangle^2$: average sfermion mass
- Δm^2: deviations from a degenerate sfermion (s)pectrum

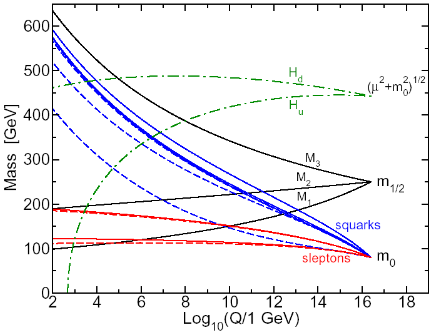
The problem

Experimental bounds

$$\left|\delta^{d}_{12_{LL}}\right| < 2.2 \times 10^{-4}$$

$$\left|\delta^{e}_{12_{LL}}\right| < 6.0 \times 10^{-4}$$

Running effects



Adjusting the δ

$$\delta(M_X) = \delta(M_W)\frac{m^2_{\tilde{f}}(M_X)}{m^2_{\tilde{f}}(M_W)}$$

D-term contribution

$U(1)$ example

$$(D - \mathrm{term})^2 = g^2 \left(|\phi|^2 - c|\bar{\phi}|^2 + c_f |\tilde{f}|^2 + (\ldots) \right)^2$$

Expand the D-term and identify sfermion mass terms:

$$\Delta m^2_{\tilde{f}} = 2 c_f \langle D^2 \rangle$$

With:

$$\langle D^2 \rangle \equiv g^2 \langle |\phi|^2 - c|\bar{\phi}|^2 \rangle$$

Upper bound on theoretical prediction

Unitarity

$$\delta_{12} = \frac{2\langle D^2 \rangle}{\langle m_{\tilde{f}} \rangle^2} (V_{11} c_1 V_{21}^* + V_{12} c_2 V_{22}^* + V_{13} c_3 V_{23}^*)$$

Due to unitarity of V:

$$\rightarrow |\delta_{12}| < \left| \frac{\langle D^2 \rangle}{\langle m_{\tilde{f}} \rangle^2} \right| \mathrm{Max} \left| c_i - c_j \right|$$

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Potentials and vevs

Familon vevs

$$V = g^2 \left(|\phi|^2 - c|\bar{\phi}|^2 \right)^2 + m^2|\phi|^2 + \bar{m}^2|\bar{\phi}|^2 + \left(\phi\bar{\phi} - \Lambda^2 \right)^2$$

If $c > 0$ and $\langle\phi\rangle, \langle\bar{\phi}\rangle \gg m, \bar{m}$:

$$\langle D^2 \rangle = g^2 \langle |\phi|^2 - c|\bar{\phi}|^2 \rangle$$
$$\approx -\frac{m^2 - \bar{m}^2/c}{4}$$

Predicted δ

δ_{12}

$$|\delta_{12}| < \left| \frac{m^2 - \bar{m}^2/c}{4\langle m_{\tilde{f}} \rangle^2} \right| \mathrm{Max} \left| c_i - c_j \right|$$

Solutions

- $c = 1$ and $m^2 = \bar{m}^2$

Or

- $m^2, \bar{m}^2 \ll \langle m_{\tilde{f}} \rangle^2$

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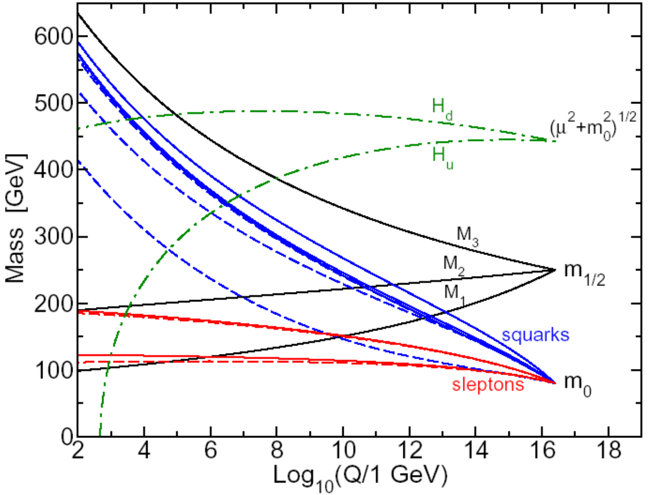
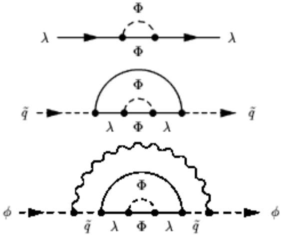
SUGRA: Common masses



Gauge mediation: Suppressed masses



Loop suppressions

ϕ, $\bar{\phi}$ are SM singlets; gauge mediated $m^2, \bar{m}^2$ suppressed by:

- loop factors
- family coupling constant g

Summary

Family symmetry flavour problem

- Presents serious constraints (1 flavon models disfavored).
- Conclusions are general (non-Abelian, more familons).
- There are simple solutions.