On the calculation of threshold corrections in the constrained Exceptional Supersymmetric Standard Model (cE_6SSM)

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Exceptional Supersymmetric Standard Model (E$_6$SSM)

[S. F. King, S. Moretti, R. Nevzorov, Phys.Rev.D73:035009 (2006)]

- E_6 inspired model with an extra $U(1)$ gauge symmetry
- solves μ problem of MSSM dynamically
- broken down $E_6 \to SU(3)_\mathrm{c} \times SU(2)_\mathrm{L} \times U(1)_Y \times U(1)_N$

Matter content: 3 complete fundamental 27 representations of the E_6 plus 2 Higgs like doublets H', $\overline{H'}$

Table: Matter content of the E$_6$SSM ($i = 1, 2, 3$)

Q_i, u_i^c, d_i^c, L_i, e_i^c, N_i^c	Standard Model matter
S_i	$U(1)_N$ singlet fields
H_{1i}, H_{2i}	Higgs like fields
X_i, $\overline{X}_i$	exotic colored matter
H', $\overline{H'}$	extra Higgs like doublets

Exceptional Supersymmetric Standard Model (E_6SSM)

Approximate the Superpotential:

- imposing a $Z_2^{B/L}$ (analog to R parity) and (approximate) Z_2^H symmetry to evade rapid proton decay and FCNC
- integrate out: N_i^c, H', $\overline{H'}$
- keep dominant terms

$\Rightarrow$

$$\begin{aligned} W_{\mathrm{E_6SSM}} &\approx h_t(H_u Q)t^c + h_b(H_d Q)b^c + h_\tau(H_d L)\tau^c \\ &\quad + \lambda_i S_3(H_{1i}H_{2i}) + \kappa_i S_3(X_i \overline{X}_i) \\ &\quad (i = 1, 2, 3) \end{aligned}$$

Constrained Exceptional Supersymmetric Standard Model

[P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, Phys.Rev.D80:035009 (2009)]

Constrained model defined by mass universality at M_X:

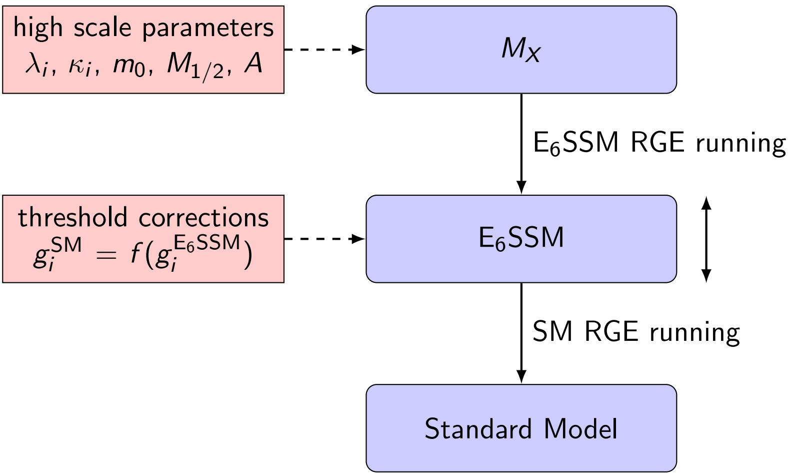
$$\begin{aligned} \text{scalar masses} &= m_0, \\ \text{Gaugino masses} &= M_{1/2}, \\ \text{trilinear couplings} &= A \end{aligned}$$

Input parameters for the constrained model:

$$\begin{aligned} & \lambda_i(M_X), \kappa_i(M_X), m_0, M_{1/2}, A \\ \Leftrightarrow \quad & \lambda_i(M_X), \kappa_i(M_X), v, \tan\beta, \langle S_3 \rangle \end{aligned}$$

Our aim: More precise particle masses

Why do we need threshold corrections?



Matching procedure

Most important: Gauge coupling g_3 of $SU(3)_c$, since $\beta_3^{1L} = 0$

effective theory: $\mathcal{L}^{SM} = -\hat{g}_3\, \bar{\hat{\psi}} \hat{\not{A}}^a T^a \hat{\psi} + \dots$

full theory: $\mathcal{L}^{E_6SSM} = -g_3\, \bar{\psi} \not{A}^a T^a \psi + \dots$

Matching conditions:

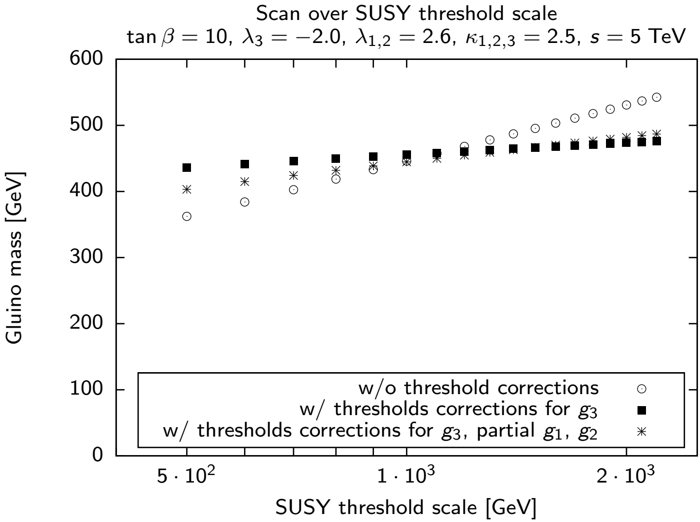
$$\Gamma^{E_6SSM}_{\psi,\bar{\psi}} = \Gamma^{SM}_{\psi,\bar{\psi}}, \qquad \Gamma^{E_6SSM}_{A^a_\mu,A^b_\nu} = \Gamma^{SM}_{A^a_\mu,A^b_\nu}, \qquad \Gamma^{E_6SSM}_{A^a_\mu,\psi,\bar{\psi}} = \Gamma^{SM}_{A^a_\mu,\psi,\bar{\psi}}$$

$\Rightarrow$

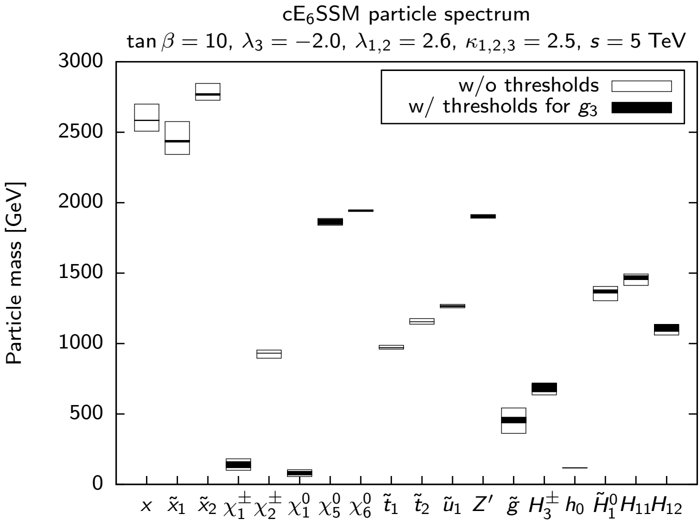
$$g_3^{E_6SSM,\overline{DR}} = g_3^{SM,\overline{MS}} + \frac{g_3^3}{(4\pi)^2}\Bigg\{\frac{1}{2} - 2\log\left(\frac{m_{\tilde{g}}}{\mu}\right) - \frac{1}{6}\sum_{\tilde{q}}\log\left(\frac{m_{\tilde{q}}}{\mu}\right) - \frac{2}{3}\sum_{x}\log\left(\frac{m_x}{\mu}\right) - \frac{1}{6}\sum_{\tilde{x}}\log\left(\frac{m_{\tilde{x}}}{\mu}\right)\Bigg\}$$

[J. L. Hall, Nucl.Phys.B178 (1981)]

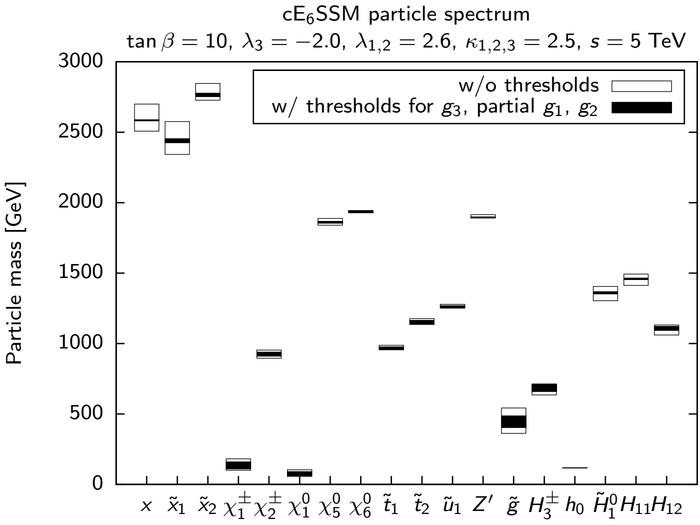
Matching scale dependence



Matching scale dependence



Matching scale dependence



Conclusions and Future plans

Conclusions:

- First study of threshold effects in cE_6SSM
- Very split spectrum $\longrightarrow$ threshold corrections important
- threshold corrections reduce dependency of masses upon matching scale

Future plans:

- complete E_6SSM threshold corrections for g_1, g_2 (partly done already)
- E_6SSM threshold corrections for Yukawa couplings