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Corrections to the trilinear Higgs couplings in the NMSSM

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Motivations for studying trilinear Higgs couplings

Most important question after discovery of the Higgs boson:

Is it SM Higgs boson or are there hints for BSM physics?

- measurement of trilinear Higgs couplings allows reconstruction of Higgs potential
  e.g. in the Standard Model:

$$V_{Higgs} = \mu^2(\phi^\dagger\phi) + \frac{1}{2}\lambda(\phi^\dagger\phi)^2 \qquad \lambda = \frac{m_h^2}{v^2}, \;\; \mu^2 = -\frac{1}{2}m_h^2$$

$$\Rightarrow \lambda_{hhh} = \frac{3m_h^2}{v}$$

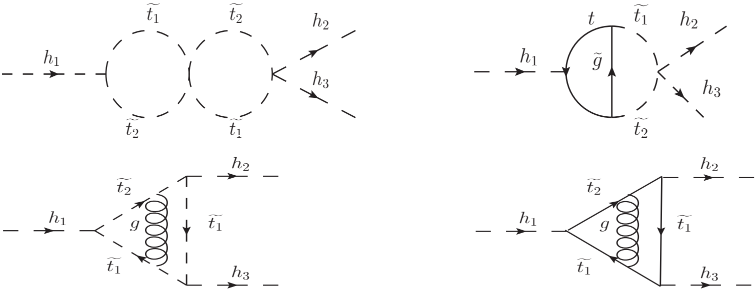
- Trilinear couplings: subject to radiative corrections
  $\Rightarrow$ calculation of higher order corrections necessary
- measurement of trilinear Higgs couplings at LHC: challenging but possible

Calculation of the dominant two loop corrections

Two loop calculation in Feynman diagram approach

Approximations:

- calculation done in gaugeless limit: $\Rightarrow e, g_1, g_2 = 0$
- only two loop corrections of order $\mathcal{O}(\alpha_t \alpha_s)$ $\Rightarrow$ only SUSY-QCD corrections
- external momenta set to $\Rightarrow p_i = 0$



Calculation of the dominant two loop corrections

After regularization via DRED we encounter integrals of type:

$$C^2 \int \mathrm{d}^D l_1\, \mathrm{d}^D l_2\, \frac{(l_1^2)^{\alpha_1} (l_2^2)^{\alpha_2} (l_1 \cdot l_2)^{\alpha_3}}{(l_i^2 - m_1^2)(l_i^2 - m_2^2)(l_i^2 - m_3^2)(l_i^2 - m_4^2)(l_i^2 - m_5^2)}$$

$l_i = l_1, l_2, l_1 - l_2 \qquad \alpha_i = 0, 1, 2$

Simplification of integrals with Mathematica package TARCER: [R.Mertig,R.Scharf]

- TARCER reduces integrals of more general type

$$C^2 \int \mathrm{d}^D l_1\, \mathrm{d}^D l_2\, \frac{(l_1)^{\alpha_1} (l_2)^{\alpha_2} (l_1 \cdot l_2)^{\alpha_3} (l_1 \cdot p)^{\alpha_4} (l_2 \cdot p)^{\alpha_5}}{D_1^{\nu_1} D_2^{\nu_2} D_3^{\nu_3} D_4^{\nu_4} D_5^{\nu_5}}$$

  to set of master integrals (via Tarasov algorithm) [O.V.Tarasov]

  $D_j = ((l_i - p_j)^2 - m_j^2)$

Calculation of the dominant two loop corrections

For our case: all integrals reducible to one loop vacuum bubble

$$A_0 = C \int \mathrm{d}^D l_1 \frac{1}{l_1^2 - m_1^2}$$

and two loop vacuum bubble

$$K_0 = C^2 \int \mathrm{d}^D l_1 \mathrm{d}^D l_2 \frac{1}{(l_1^2 - m_1^2)(l_2^2 - m_2^2)((l_1 - l_2)^2 - m_3^2)}$$

A_0 and K_0 analytically known and expandable in series in ϵ

$\Rightarrow$ UV divergences of two loop diagrams appear as:

- single poles $\propto \frac{1}{\epsilon}$
- and double poles $\propto \frac{1}{\epsilon^2}$

Conclusion

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- The determination of trilinear Higgs-couplings allows the reconstruction of the Higgs potential

- The calculation of the dominant two loop corrections is conveniently done with the Mathematica package TARCER

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Thank you for listening!