

4.2.2 Method implemented in FlexibleSUSY and SARAH/SPheno

The hybrid calculations implemented in **FlexibleSUSY** [24, 22] and **SARAH/SPheno** [25] use a physical matching condition to incorporate the suppressed terms to all orders into the quartic Higgs coupling of the Standard Model: At the SUSY scale M_S , both codes require the equality of the physical Higgs pole masses of the Standard Model and the MSSM,

$$(M_h^2)_{\text{SM}} \stackrel{!}{=} (M_h^2)_{\text{MSSM}}, \quad (6)$$

where $(M_h^2)_{\text{SM}}$ and $(M_h^2)_{\text{MSSM}}$ denote the squared pole masses of the SM-like Higgs boson, calculated in the Standard Model and in the MSSM, respectively. By decomposing $(M_h^2)_{\text{SM}}$ into tree-level and loop contributions as [\[AV: Use consistent normalization for \$\lambda\$ and \$v\$.\]](#)

$$(M_h^2)_{\text{SM}} = \lambda(M_S)v^2(M_S) + (\Delta m_h^2)_{\text{SM}}, \quad (7)$$

the $\overline{\text{MS}}$ quartic Higgs coupling λ of the Standard Model can be calculated at the scale M_S from Eq. (6) as

$$\lambda(M_S) = \frac{1}{v^2(M_S)} \left[(M_h^2)_{\text{MSSM}} - (\Delta m_h^2)_{\text{SM}} \right]. \quad (8)$$

The Higgs pole mass $(M_h^2)_{\text{MSSM}}$ and the Standard Model loop contributions $(\Delta m_h^2)_{\text{SM}}$ on the r.h.s. of Eq. (8) are numerically inserted into the equation. Both terms contain large logarithms, which numerically cancel completely at the order at which both terms are evaluated. Since no expansion of the r.h.s. of Eq. (8) is performed, $\lambda(M_S)$ includes all suppressed terms of that order. Special care must be taken in the evaluation of the r.h.s. of Eq. (8) to avoid the occurrence of uncanceled large logarithmic higher-order corrections, which may, if present, spoil the precision of the calculation. For a detailed discussion on potential non-cancellations of such large higher-order logarithms see Ref. [22]. After $\lambda(M_S)$ has been calculated, 3-loop renormalization group running to the top quark pole mass scale M_t is performed. At this scale the Higgs pole mass is calculated in the Standard Model in the $\overline{\text{MS}}$ scheme as

$$M_h^2 = \lambda(M_t)v^2(M_t) + (\Delta m_h^2)_{\text{SM}}. \quad (9)$$

The Higgs pole mass calculated with this approach contains the non-logarithmic MSSM and Standard Model loop contributions from r.h.s of Eqs. (8)–(9), respectively, as well as the large logarithmic corrections in a resummed form.

Due to the simplicity of Eq. (8), the hybrid method implemented in **FlexibleSUSY** and **SARAH/SPheno** has been automatized and can be applied to a large class of Standard Model extensions, such as the MSSM, NMSSM, MRSSM or $E_6\text{SSM}$, for example.