On this website you can access the three-loop β-functions for the MSSM including "standard" soft breaking terms. The theory is defined by the superpotential

$$W = H_2QY_tt^c + H_1QY_bb^c + H_1LY_\tau\tau^c + \mu H_1H_2 \tag{1}$$

where Y_t, Y_b, Y_τ are 3×3 Yukawa matrices, and the soft supersymmetry breaking Lagrangian is

$$\begin{aligned} L_{\mathrm{SOFT}}^{(1)} =& Q^*m_Q^2Q + (t^c)^*m_{t^c}^2t^c + (b^c)^*m_{b^c}^2b^c + L^*m_L^2L + (\tau^c)^*m_{\tau^c}^2\tau^c \\ &+ m_1^2H_1^*H_1 + m_2^2H_2^*H_2 + \left[m_3^2H_1H_2 + \sum_{i=1}^{3}\tfrac{1}{2}M_i\lambda_i\lambda_i + \mathrm{h.c.}\right] \\ &+ \left[H_2Qh_tt^c + H_1Qh_bb^c + H_1Lh_\tau\tau^c + \mathrm{h.c.}\right] \end{aligned} \tag{2}$$

Here $m_Q^2, m_{t^c}^2, m_{b^c}^2, m_{\tau^c}^2, h_t, h_b, h_\tau$ are also 3×3 matrices.

We have also included n_5 and n_{10} sets of SU_5 $5(\overline{5})$ and $10(\overline{5})$ representations respectively (with only gauge interactions).

The program contains the anomalous dimensions of the various chiral supermultiplets, for example

$$\gamma_Q = \frac{1}{16\pi^2}\gamma_Q^{(1)} + \frac{1}{(16\pi^2)^2}\gamma_Q^{(2)} + \frac{1}{(16\pi^2)^3}\gamma_Q^{(3)} + \cdots \tag{3}$$

and the gauge β-functions, for example

$$\beta_{g_3} = \frac{1}{16\pi^2}\beta_{g_3}^{(1)} + \frac{1}{(16\pi^2)^2}\beta_{g_3}^{(2)} + \frac{1}{(16\pi^2)^3}\beta_{g_3}^{(3)} + \cdots \tag{4}$$

and the β-functions for the various Yukawa couplings, for example $\beta_{Y_t} = \frac{1}{16\pi^2}\beta_{Y_t}^{(1)} + \frac{1}{(16\pi^2)^2}\beta_{Y_t}^{(2)} + \frac{1}{(16\pi^2)^3}\beta_{Y_t}^{(3)} + \cdots$

and the soft breaking β-functions:

- The gaugino β-functions, $\beta_M^{(L)}$
- The ϕ^3 soft interaction β-functions, $\beta_{h_{t,b,\tau}}^{(L)}$.
- The $\phi\phi^*$ soft mass β-functions, $\beta_Q^{(L)}$

We use the usual SU_5 normalisation for the U_1 coupling, $g_1^2 = \frac{5}{3}(g')^2$, and suppress throughout the $16\pi^2$ factors.

In the program file, the following abbreviations and notation are used:

$$\begin{aligned} a_1 \equiv& g_1^2 \quad \text{etc} \\ Yt \equiv& Y_t \quad \text{etc} \\ Ytc \equiv& Y_t^\dagger \quad \text{etc} \\ k \equiv& 6\zeta(3) \end{aligned}$$