The integrand is a holomorphic function whereas the factor $Z_X^{-1/2}$ is real. Therefore, due to the non-renormalization theorem [15, 16], there is no quantum correction in the second line in (6). This means that w_a does not receive any quantum correction at all scales. On the other hand, the integrand of the first term in (6) is not a holomorphic function and therefore the coefficients k_i are renormalized by the visible sector gauge interactions and the hidden sector coupling λ in (5). They then satisfy the RGE

$$\frac{d}{dt}k_i(t) = \gamma(t)k_i(t) \\ -\frac{1}{16\pi^2}\sum_{a=1}^{3} 8C_2^a(R_i)g_a^6(t)G_a, \quad G_a \equiv w_a w_a^\dagger. \quad (8)$$

The second term is the leading visible sector contribution. In the first term $\gamma(t)$ is the anomalous dimension at $t = \ln(\mu/M)$ arising from the hidden sector interactions (5). The anomalous dimension in the lowest order in λ is

$$\gamma(t) = \frac{\lambda(t)\lambda^\dagger(t)}{2\pi^2}, \quad (9)$$

where $\lambda(t)$ is the running hidden sector Yukawa coupling which renormalizes according to

$$\frac{d\lambda(t)}{dt} = \frac{3}{8\pi^2}\lambda^3(t). \quad (10)$$

The RGE (8) are solved as

$$k_i(t) = \exp\left(-\int_t^0 dt'\gamma(t')\right)k_i(0) \quad (11) \\ +\frac{1}{16\pi^2}\sum_{a=1}^{3}8C_2^a(R_i)\int_t^0 ds g_a^6(s)\exp\left(-\int_t^s dt'\gamma(t')\right)G_a.$$

Using this expression, the scalar masses of the visible sector including the RG effects are described by

$$m_i^2(t) = k_i(t)\Lambda^2, \quad (12)$$

with

$$k_i(0) = 2\sum_{a=1}^{3}\left(\frac{\alpha_a(M)}{4\pi}\right)^2 C_2^a(R_i). \quad (13)$$

Here the gauge couplings run according to the standard 1-loop formula,

$$\frac{1}{\alpha_a(\mu)} = \begin{cases} \frac{1}{\alpha_a(M_Z)} - \frac{1}{2\pi}b_a \ln\frac{M_S}{M_Z} - \frac{1}{2\pi}b_a^S \ln\frac{\mu}{M_S}, & (\mu > M_S) \\ \frac{1}{\alpha_a(M_Z)} - \frac{1}{2\pi}b_a\ln\frac{\mu}{M_Z}, & (\mu \le M_S) \end{cases} \quad (14)$$

where $(b_1^S, b_2^S, b_3^S) = (-3, 1, 33/5)$ for the MSSM and $(b_1, b_2, b_3) = (-7, -19/6, 41/10)$ for the standard model gauge couplings. M_Z and $M_{\rm S}$ are the Z-boson mass and a typical soft mass scale, respectively.

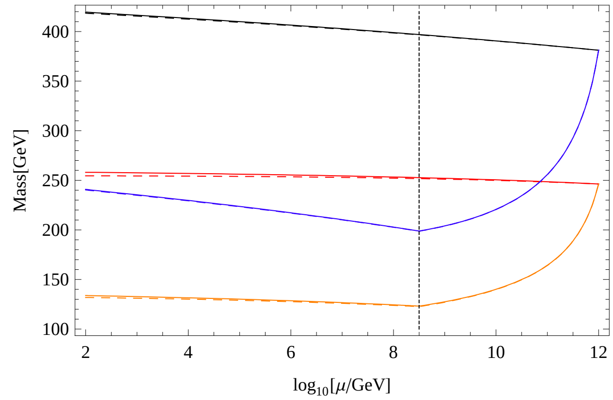

FIG. 1: The slepton mass RG flows with and without the hidden sector effects. The upper curves (black and blue) are the left-handed, and the lower curves (red and orange) are the right-handed sleptons. The 1st and the 3rd generations are respectively indicated by the solid and the dashed curves. The curves with sharp decline (blue and orange) above the hidden scale $M_{\rm hid} = 10^{8.5}$ GeV (indicated by the vertical dotted line) are the flows including the hidden sector effects. The straight lines (black and red) are the flows without the hidden sector effects. We have chosen $M = 10^{12}$ GeV, $\lambda = 3.8$ and $\tan\beta = 10$.

III. THE HIDDEN SECTOR RENORMALIZATION GROUP FLOW

We shall be interested in the low energy mass spectra, in particular determination of the NLSP. The hidden sector renormalization affects the mass RG flows between the messenger scale $\mu = M$ and the hidden scale $\mu = M_{\rm hid}$. Eq. (8) implies that the RGE for the MSSM soft scalar masses are modified as,

$$\frac{dm_i^2}{dt} \to \frac{dm_i^2}{dt} + \frac{\lambda\lambda^\dagger}{2\pi^2}m_i^2, \quad (15)$$

while those for the other masses and couplings are unaltered (see, for example, [17]). Below the hidden scale, the hidden sector fields are integrated out and all the masses and the couplings evolve according to the standard MSSM RGE. The low energy mass spectrum is obtained by integrating the RGE, from the messenger scale to the hidden scale with the hidden sector effects (15) included, and then down to the electroweak scale in the standard way. In this section we present numerical study of the MSSM RGE including the hidden sector effects at one-loop order. The non-standard parts of the RGE are listed in Appendix A.

In our computations we made following approximations. For simplicity only the $(3, 3)$ family component of the three Yukawa matrices, and only the $(3, 3)$ family component of the trilinear A-term matrices, are set to be non-zero. The latter are set to vanish at the messenger scale. Throughout our analysis we use following values: $\tan\beta = 10$, the soft mass scale $M_S = 500$ GeV, and