Assuming that S' acquires a VEV around 10^{13} GeV, we obtain that M_V is around 10^{13} GeV.

By the way, the other Yukawa coupling terms among S, the SM fermions and Higgs fields might have the prefactor $\left(\frac{S^2}{M_{\rm Pl}^2}\right)^n \left(\frac{A}{M_{\rm Pl}}\right)^m (...)$ ($n \geq 1$ or $m \geq 1$). Thus, these Yukawa coupling terms are supressed by at least the Planck scale square and then are negligible since S's VEV is around the TeV scale. In this paper, we only consider the minimal Kähler potential. In general, the dimension-six operators of the form $SS^\dagger \phi\phi^\dagger / M_{\rm Pl}^2$ cannot be forbidden by any symmetry where ϕ denotes the SM fermions and Higgs fields. These dimension-six operators can induce DM two-body decay through derivative couplings [16]. However, their contributions to the CR are also ignorable since these operators are suppressed by the Planck scale square as well.

III. DECAY AND STABLE DARK MATTERS

A. The CMSSM Benchmark Point for CDMS II Experiment

The CMSSM with the LSP neutralino as DM has been studied extensively before. Typically, the LSP neutralino with mass about tens of GeV is in tension with the lightest CP-even Higgs boson mass whose low bound from the LEP is 114 GeV. Especially, we require that the LSP neutralino relic density be small about half of the total DM relic density, *i.e.* $\Omega_{\widetilde{N}_1^0} h^2 \sim 0.06$. In this paper, we do not scan all the viable parameter space. We only consider a CMSSM benchmark point that satisfies all the constraints. We choose the following five free parameters at the GUT scale

$$m_0 = 310 \text{GeV}, \quad m_{1/2} = 250 \text{GeV}, \quad A_0 = -1040, \quad \tan\beta = 30, \quad \text{sign}(\mu) = +1. \qquad (13)$$

As expected, this benchmark point is in the coannihilation region [34] with small mass difference between the light stau $\widetilde{\tau}_1$ and LSP neutralino, *i.e.*, $m_{\widetilde{\tau}_1} - m_{\widetilde{N}_1^0} \leq 8$ GeV. Such benchmark point is not interesting previously since the LSP neutralino relic density is smaller than the observed whole DM relic density. However, it is fine in our models since we have two DM particles. With MicrOMEGAs 2.0 [35], we obtain the LSP neutralino relic density

$$\Omega_{\widetilde{N}_1^0} h^2 \approx 0.08 \; . \qquad (14)$$

Moreover, the mass of the LSP neutralino is about 101.6 GeV. And the spin-independent cross section between the LSP neutralino and nucleon is about $\sigma_{SI} \approx 5 \times 10^{-9}$ pb. Although this cross section is a little bit small, we can still explain the CDMS II experiment due to the uncertainties of the QCD effects in the calculations.

It is necessary to address the mass spectrum of this benchmark point in details for the following calculations. The lightest neutralino $\widetilde{N}_1$ is bino-like, while the heavy neutralinos