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Viability of Boosted Light Dark Matter in a Two-Component Scenario

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We study the boosted dark matter (BDM) scenario in a two-component model. We consider a neutrinophilic two-Higgs doublet model (ν2HDM), which comprises of one extra Higgs doublet and a light right-handed neutrino. This model is extended with a light ($\sim$ 10 MeV) singlet scalar DM ϕ_3, which is stabilized under an extra dark $Z_2^{\rm DM}$ symmetry and can only effectively annihilate through the CP even scalar H. While the presence of a light scalar H modify the oblique parameters to put tight constraints on the model, introduction of vectorlike leptons (VLL) can potentially salvage the issue. These vectorlike doublet N and vectorlike singlet χ are also stabilized through the dark $Z_2^{\rm DM}$ symmetry. The lightest vectorlike mass eigenstate ($\chi_1 \sim 100$ GeV) is the second DM component of the model. Individual scalar and fermionic DM candidates have Higgs/Z mediated annihilation, restricting the fermion DM in a narrow mass region while a somewhat broader mass region is allowed for the scalar DM. However, when two DM sectors are coupled, the annihilation channel $\chi_1\chi_1 \to \phi_3\phi_3$ opens up. As a result, the fermionic relic density decreases, and paves way for broader fermionic DM mass region with under-abundant relic: a region of $[30-70]$ GeV compared to a narrower $[40-50]$ GeV window for the single component case. On the other hand, the light DM ϕ_3 acquires significant boost from the annihilation of χ_1, causing a dilution in the resonant annihilation of ϕ_3. This in turn increases the scalar DM relic allowing a smaller mass region compared to the individual case. The exact and underabundant relic is achievable in a significant parameter space of the two-component model where the total DM relic is mainly dominated by the fermionic DM contribution. The scalar DM is found to be sub-dominant or equally dominant ($\sim 5\% - 55\%$ of total DM) with significant boost which can be detected in experiments.

Track type

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