Contribution ID: **28** Type: **Talk**

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

Wednesday 20 December 2023 16:45 (15 minutes)

We study the two-component boosted dark matter (DM) scenario in a neutrinophilic two-Higgs doublet model (ν2HDM), which comprises one extra Higgs doublet with a MeV scale CP-even scalar H. This model is extended with a light (~ 10 MeV) singlet scalar DM $\phi 3$, which is stabilized under the existing Z2 symmetry and can only effectively annihilate through scalar H. As the presence of a light H modifies the oblique parameters to put tight constraints on the model, the introduction of vectorlike leptons (VLL) can potentially salvage the issue. These additional vector-like doublet N and one vector-like singlet χ are also stabilized through the Z2 symmetry. The lightest vectorlike mass eigenstate $\chi 1$ (~ 100 GeV) can be the potential 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. In a coupled scenario, light DM $\phi 3$ gets its boost from the $\chi 1$ annihilation while the fermionic DM opens up a new annihilation channel $\chi 1\chi 1 \longrightarrow \phi 3\phi 3$: decreasing the relic density. This paves the way for more fermionic DM mass with an under-abundant relic, a region of [35-60] GeV compared to a smaller [40-50] GeV window for the single component fermion DM. On the other hand, the $\phi 3$ resonant annihilation gets diluted due to boosting effects in kinematics, which increases the DM relic leading to a smaller allowed region. To achieve an under-abundant relic, the total DM relic will be dominated by the $\chi 1$ contribution. While there is a region with $\phi 3$ contribution dominating the total DM, the combined relic becomes over-abundant. Therefore, a sub-dominant (~ 5%) boosted scalar is the most favorable light DM candidate to be probed for detection.

Designation

Student

Reference publication/preprint

arxiv number 2310.09349

Institution

SRM University AP

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Session Classification: Parallel: DM + neutrino