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Reopening the Z portal with semi-annihilations

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In one-component dark matter (DM) scenarios is commonly assumed that a scalar WIMP must either be part of an $SU(2)_L$ multiplet with zero hypercharge or have suppressed vector interactions with the Z gauge boson to circumvent stringent direct detection (DD) bounds. In this work, we demonstrate that multi-component scenarios with a dark scalar doublet exhibiting vector-like interactions with the Z boson are also compatible with bounds arising from DD searches. Specifically, we consider a simple extension of the Standard Model wherein the dark sector comprises a doublet and a complex singlet ϕ, both charged under a Z_6 symmetry. We find that semi-annihilation processes drastically reduce the relic abundance of the neutral component of the doublet, H^0, sufficiently attenuating the effects of its large Z-mediated elastic scattering cross-section with nucleons to satisfy the DD constraints. Although the contribution of H^0 to the total relic abundance is nearly negligible, with ϕ dominating, both dark matter components are expected to be detectable in ongoing and future DD experiments. The viability of the model is tested against several theoretical and experimental constraints, resulting in a parameter space featuring a non-degenerate mass spectrum at the electroweak scale.

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