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Closing the window on WIMP dark matter

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We study scenarios where Dark Matter is a weakly interacting particle (WIMP) embedded in an ElectroWeak (EW) multiplet. In particular, we consider both real SU(2) representations with hypercharge $Y = 0$, that automatically avoid direct detection constraints from tree-level Z-exchange, and complex ones with $Y \neq 0$. In the latter case, the minimal inelastic splitting between the DM and its EW neutral partner allows only multiplets with $Y = 1/2$ and $Y = 1$. We compute for the first time \emph{all the calculable thermal masses} for scalar and fermionic WIMPs up to largest multiplets allowed by perturbative unitarity, including Sommerfeld enhancement and bound states formation at leading order in gauge boson exchange and emission. We then outline a strategy to probe these scenarios at future experiments. Real candidates and, for the minimal allowed splitting, most of the complex multiplets can be fully probed at future large exposure direct detection experiments. In the complex case, direct detection can cover most of the parameter space spanned by mass splittings, except for limited regions falling below the neutrino floor due to accidental cancellations. The existence of these regions represents a major motivation for a future muon collider, which can efficiently probe all EW multiplets up to the 5-plets by means of missing mass, stub and charged track searches.

In-person participation

Yes

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