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A Systematic Effective Operator Analysis of Semi-Annihilating Dark Matter

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Semi-annihilation is a generic feature of dark matter theories stabilized by symmetries larger than a Z_2. It contributes to thermal freeze out, but is irrelevant for direct and collider searches. This allows semi-annihilating dark matter to avoid those limits in a natural way. We use an effective operator approach to make the first model-independent study of the associated phenomenology. We enumerate all possible operators that contribute to $2 \to 2$ semi-annihilation up to dimension 6, plus leading terms at dimension 7. We find that when the only light states charged under the dark symmetry are dark matter, the model space is highly constrained. Only fifteen operators exist, and just two for single-component dark sectors. If there can be additional light, unstable "dark partner" states the possible phenomenology greatly increases, at the cost of additional model dependence in the dark partner decay modes. We also derive the irreducible constraints on models with single-component dark matter from cosmic ray searches and astrophysical observations. We find that for semi-annihilation to electrons and light quarks, the thermal relic cross sections can be excluded for dark matter masses up to 100 GeV. However, significant model space for semi-annihilating dark matter remains.

Presentation type

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