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Dark matter bound states: where do we stand?

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In a variety of theories, Dark Matter (DM) interacts with gauge bosons or scalars that induce long-range interactions because of repeated soft exchanges. Remarkably, the inclusion of bound-state effects for DM annihilation has been recently shown to have a large impact on the relic density and, therefore, on the parameters of a given model to be compatible with observations. At the same time, it is manifestly subtle and complicated to include bound-state dynamics in a thermal medium due to the intricate interplay between non-relativistic and thermal energy scales. Starting from a thermal field theoretical formulation of the problem, we use an effective field theory approach to describe bound-state formation and dissociation, Sommerfeld effect, DM thermal masses and interaction rates. We show the phenomenological impact of such framework for wimp-like models with mediators to the visible sector. Moreover, we discuss some shortcomings in the current rate equations that limit the validity of existing results in the literature for even simpler dark matter models.

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