Contribution ID: **437** Type: **Parallel Talk**

Bound-state effects for dark matter models: from the relic density to experimental searches

Thursday, 7 July 2022 11:30 (15 minutes)

Dark sectors containing light vectors or scalars may feature sizeable self-interactions between dark matter (DM) particles and are therefore of high phenomenological interest. Self-interacting dark matter appears to reproduce the observed galactic structure better than collisionless DM and may offer a dynamical explanation for the scaling relations governing galactic halos all the way up to clusters of galaxies. On top of being desirable from the phenomenological and observational points of views, the possibility of a richer dark sector, that comprises more than one particle, is fairly common in many DM models.

Furthermore, the existence of light, i.e. with masses much smaller than that of the actual DM particles, mediators may affect the DM dynamics in multiple ways.
Most notably, whenever DM particles are slowly moving with non-relativistic velocities, light mediators can induce bound states in the dark sector in the early universe and/or in the dense environment of present-day haloes. As for the above-threshold states, the effect of repeated mediator exchange manifests itself in the so-called Sommerfeld enhancement for an attractive potential.

In this talk we review state-of-art effective field theories techniques, both at zero and at finite temperature, that allows for the determination of rates that are crucial for an accurate determination of the DM energy density: bound-state formation and dissociation, pair annihilations and bound-state decays. Depending on the model, bound-state effects can lead to a substantial effect and rather different combinations of DM masses and couplings are found to reproduce the observed energy density. This calls for a reassessment of DM phenomenology due to the interplay between the model parameters that fix the relic density and guide the experimental strategies.

We address and discuss various DM models, that comprise the case of QCD colored co-annihilating partners, fermionic and scalar DM with self-interactions mediated by different mediators (scalar, pseudoscalar, vector and axial vector). We explore and report on the present reach of complementary experimental searches, including the LHC and XENON, and future prospects for the DARWIN experiment and Cherenkov Telescope Array (CTA).

In-person participation

No

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Session Classification: Dark Matter

Track Classification: Dark Matter