Contribution ID: **29** Type: **not specified**

Opening up the Light Dark Matter Model Space with Scalar Co-SIMPs

Monday, June 26, 2023 3:00 PM (45 minutes)

In this work, we present UV completions of the recently proposed number-changing Co-SIMP freeze-out mechanism. In contrast to the standard cannibalistic-type dark matter picture that occurs entirely in the dark sector, the $3 \to 2$ process setting the relic abundance in this case requires one Standard Model particle in the initial and final states. This prevents the dark sector from overheating and leads to rich experimental signatures. We generate the Co-SIMP interaction with a dark sector consisting of two scalars, with the mediator coupling to either nucleons or electrons. In either case, \textit{the dark matter candidate is naturally light}: nucleophilic interactions favor the sub-GeV mass range and leptophilic interactions favor the sub-MeV mass range. Viable thermal models in these lighter mass regimes are particularly intriguing to study at this time, as new developments in low-threshold detector technologies will begin probing this region of parameter space. While particles in the sub-MeV regime can potentially impact light element formation and CMB decoupling, we show that a late-time phase transition opens up large fractions of parameter space. These thermal light dark matter models can instead be tested with dedicated experiments. We discuss the viable parameter space in each scenario in light of the current sensitivity of various experimental probes and projected future reach.

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