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An Elastically Decoupling Relic Within the Not-Forbidden Dark Matter Scenario

We explore the Elastically Decoupling Relic (ELDER) scenario in a general context where $3 \to 2$ annihilations play an important role in determining the late-time abundance of dark matter (DM), whether the dark sector coupling is strong or weak (the Not-Forbidden Dark Matter, or NFDM, scenario). In the conventional weakly-interacting massive particle (WIMP) paradigm the thermal relic density of DM is set by two body annihilations. There has been interest in exploring alternative DM candidates with novel freezeout scenarios, including models in which dark matter has strong number-changing self-interactions. Examples of such candidates are the Strongly Interacting Massive Particle (SIMP) and Elastically Decoupling Relic (ELDER) scenarios, in which the current DM density is determined either by the cross section of the number-changing ($3 \to 2$) self-interaction process or by the cross section of elastic scattering between the DM and the standard model (SM), respectively. In the NFDM scenario a generic mechanism was found in which $3 \to 2$ annihilations play a critical role in determining the late-time abundance of DM in any situation in which $2 \to 2$ self-annihilations within the dark sector are kinematically suppressed. In this talk I will present preliminary results which realize a freezeout scenario in which the relic abundance of DM is set by elastic scattering with the SM (the ELDER scenario) for a Dirac fermion DM charged under a dark $U(1)$ symmetry, where $3 \to 2$ annihilations play an important role in maintaining chemical equilibrium within the DM sector after thermal decoupling with the SM and until freezeout (the NFDM scenario). These results will show that the ELDER freezeout scenario can be realized even for simple and weakly coupled dark sectors, simultaneously with the NFDM mechanism in the context of a dark photon model which is compatible with all of the NFDM, ELDER, and WIMP paradigms.

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