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Warm ingredients in a cold soup: The role of warm and cold dark matter in cosmological structure formation

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The interplay between theoretical cosmology and particle physics seeks to answer fundamental questions related to our Universe's formation and constituents. Today, it is well established that dark matter (DM) accounts for nearly 30% of the cosmic energy budget [1]. Several particle physics models of DM are being extensively studied; however, there has yet to be any luck with its detection. The weakly interacting massive particles (WIMPs) are a class of cold (negligible free-streaming effects) DM (CDM) candidates whose number density evolution is dictated by the commonly known chemical freeze-out mechanism. These are one of the most theoretically motivated DM candidates because
calculations leading to the present-day DM relic density produce an interaction cross section of the weak scale. However, all the experiments dedicated to the search for WIMPs have produced null results and the ΛCDM model of cosmology, though successful in describing structure formation on large length scales, has tensions with observations on small (sub-galactic), non-linear length scales. These
shortcomings require us to move beyond the cold WIMP paradigm to explore other particle models like the feebly interacting massive particles (FIMPs) that behave as warm DM (WDM) with significant free-streaming length, washing off structures in small scales [2]. The mass of thermally produced WDM has stringent constraints from observations, hence, the idea is to look at non-thermal production mechanisms and at scenarios where the dark matter relic has a mixture of warm and cold components. In this talk I will be describing such scenarios and motivate the connection between the particle models of WDM and their cosmological impact on structure formation.

[1] B. Dutta, Indian J. Phys. 97 (2023) 3269; B.-L. Young, Front. Phys. (Beijing) 12 (2017) 121201.

[3] R. Murgia et al, JCAP 11 (2017) 046; A. Banerjee et al, Phys. Rev. D 108 (2023) 043518.

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