DARK MATTER BEYOND "WIMP" ERA

Abstract

by

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Dark matter is one of the key ingredients of the Standard Model of Cosmology. The existence of dark matter has been established from numerous astrophysical and cosmological observations, but the nature of its interaction still remains enigmatic. Assuming dark matter is a single particle thermal relic, a canonical prediction of its interaction cross section with the Standard Model particles has been developed. More specifically, a dark matter that is a weakly interacting massive particle (WIMP), can naturally produce the observed value of dark matter relic density. Miraculously, the size of the estimated cross section, in the vicinity of the weak interaction, is just within the range of current experiments, encouraging various searches to look for the direct interaction of dark matter with the visible matter. However, after more than a generation of experiments, no unambiguous signature of dark matter is detected, and most of the targeted parameter space proposed by the single particle thermal relic has been excluded. As a result, we are led to move away from the simple single particle thermal relic paradigm and explore alternative scenarios.

Here, four alternative dark matter frameworks are discussed and their phenomenological signatures are explored: 1) There are other particles in the dark sector almost degenerate with the dark matter that have efficient annihilation rate to the Standard Model. In this case, even if dark matter itself has inefficient annihilation rate to the Standard Model states, the correct relic density can be set. 2) Dark matter annihilates to a pair of meta-stable mediators, which subsequently decay to Standard Model particles; hence, the interaction of dark matter with visible particles is small, but that is not indicative that the dark matter has

a small cross section with all particles. 3) Dark matter is distinguished from its anti-particle with asymmetric abundances. The observed relic abundance is set by annihilating away the symmetric component. 4) Dark matter is decoupled from the photon thermal sector and has negligible initial abundance, but gets populated through its feeble interaction with the Standard Model.

This work argues that all of these scenarios can successfully produce the right relic density of dark matter with 'natural' size couplings while being safe from the current experimental bounds. Furthermore, some of these models have clear phenomenological signatures within the reach of the next generation experiments, and so worth investigating.