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Axion-mediated Dark Matter beyond freeze-out

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Recent experimental advances further constrain electroweak-scale WIMPs produced via thermal freeze-out, leading to a shift away from this standard paradigm. Here we consider an axion-like particle (ALP), the pseudo-Goldstone boson of an approximate $U(1)$ global symmetry spontaneously broken at a high scale f_a , as a mediator between the Standard Model (SM) particles and the dark matter (DM) particles. We explore the case where the couplings are too small to allow for DM generation via freeze-out and the mediator particle and the DM constitute a hidden sector which is thermally decoupled from the SM particles. However, alternative generation mechanisms such as freeze-in and freeze-out from a decoupled dark sector are now appropriate. Having determined the region of parameter space where the correct relic density is obtained, we then revisit experimental constraints on ALPs from electron beam dump experiments, astrophysics and rare B and K decays.

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