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Models and Constraints of PseudoGoldstone Dark Matter

Abstract

Understanding the particle nature of dark matter remains one of the key challenges in contemporary physics. Although the thermal relic picture provides a natural explanation for the observed dark matter density, the continuing absence of positive signals in direct detection experiments calls into question the simplest WIMP hypotheses. A compelling alternative scenario emerges when dark matter originates as a pseudo-Goldstone particle associated with the breaking of a global symmetry.

In this framework, the symmetry structure that generates the dark matter mass also governs its couplings, leading to interactions that diminish rapidly at low momentum transfer. We investigate a dark sector possessing an O(N) symmetry that is spontaneously broken to O(N-1), giving rise to a family of pseudo-Goldstone states. Introducing a small explicit breaking term lifts their degeneracy, leaving a single stable particle protected by a residual discrete symmetry. The remaining, nearly degenerate states can engage in coannihilation processes that significantly affect the freeze-out dynamics and determine the final relic abundance.

This symmetry-based approach offers a natural mechanism for evading direct detection bounds while preserving the successful thermal history of dark matter, and it motivates new avenues for exploration through indirect searches and collider experiments.