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Electroweak Phase Transitions Impact on Dark Matter

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This work explores how the timing and structure of electroweak symmetry breaking (EWSB) affects the freeze-out process of dark matter (DM) in the early Universe. While standard relic density calculations assume that EWSB has already occurred, recent studies show that for sufficiently heavy DM candidates, freeze-out may take place in the symmetric phase, before the Higgs field acquires a vacuum expectation value. In this regime, particle masses and interactions differ significantly, leading to large deviations in the predicted DM relic abundance.

After reviewing the mechanism of EWSB within the Standard Model and the astrophysical evidence for dark matter, this project presents recent work introducing a phase-aware approach to relic density calculations, in which the Boltzmann equation is solved with temperature-dependent inputs corresponding to the correct electroweak phase. This refined treatment highlights the limitations of the standard approach, especially for heavy DM candidates.

Looking ahead, this project aims to implement at least one model with a two-step EWSB including three distinct stages in the early Universe, where multiple scalar fields acquire vacuum expectation values at different times. The goal is to implement multi-phase freeze-out in micrOMEGAs, enabling more accurate predictions for dark matter abundance in extended models.

Field of Research/Work

Particles and Fields

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