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Dynamic Freeze-In: Impact of Thermal Masses and Cosmological Phase Transitions on Dark Matter Production

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The cosmological abundance of dark matter can be significantly influenced by the temperature dependence of particle masses and vacuum expectation values. In the paper we illustrate this point in three simple freeze-in models. The first one, which we call kinematically induced freeze-in, is based on the observation that the effective mass of a scalar temporarily becomes very small as the scalar potential undergoes a second order phase transition. This opens dark matter production channels that are otherwise forbidden. The second model we consider, dubbed vev-induced freeze-in, is a fermionic Higgs portal scenario. Its scalar sector is augmented compared to the Standard Model by an additional scalar singlet, S, which couples to dark matter and temporarily acquires a vacuum expectation value (a two-step phase transition or "vev flip-flop"). While $\langle S \rangle \neq 0$, the modified coupling structure in the scalar sector implies that dark matter production is significantly enhanced compared to the $\langle S \rangle = 0$ phases realised at very early times and again today. The third model, which we call mixing-induced freeze-in, is similar in spirit, but here it is the mixing of dark sector fermions, induced by non-zero hSi, that temporarily boosts the dark matter production rate. For all three scenarios, we carefully dissect the evolution of the dark sector in the early Universe. We compute the DM relic abundance as a function of the model parameters, emphasising the importance of thermal corrections and the proper treatment of phase transitions in the calculation.

Summary

For the talk I will focus on one of these three models and elaborate how thermal corrections can have a significant impact on the relic abundance of dark matter compared to the vanilla (non-thermally corrected) calculation.

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