

Production of Feebly Interacting particles at Finite Temperature

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Models of feebly-interacting Dark Matter (DM) have gained popularity due to the non-observation of DM in direct detection experiments. Unlike DM freeze-out, which occurs when the dark sector particles are non-relativistic, feebly-interacting DM is primarily produced at temperatures corresponding to the heaviest mass scale involved in the production process. Consequently, incorporating finite temperature corrections becomes essential for an accurate prediction of the relic density. However, current calculations are often performed at either zero temperature or rely on thermal masses to regulate infrared divergences. In our study, we utilize the Closed-Time-Path (CTP) formalism to compute the production rate of feebly-interacting DM associated with a gauge charged parent. We compare our results with the aforementioned approaches such as the insertion of thermal masses, zero temperature calculations and a recent calculation that interpolates between finite temperature results in the ultra-relativistic and non-relativistic regime. Furthermore, we discuss the applicability and feasibility of these different approaches for phenomenological studies.

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