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# The Sommerfeld Effect at Finite Temperature

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The understanding of theoretical uncertainties in the production mechanism of dark matter (DM) particles in the Early Universe has become an important topic from the viewpoint of the percent-level accuracy in the observational determination of the relic abundance. We consider the case where heavy DM self-interacts via t-channel exchange of a light gauge boson, leading to a Sommerfeld-enhanced annihilation rate during the freeze-out. The refinement of the relic abundance prediction including this effect has extensively been studied in the literature and is well understood in the context of the standard computation in vacuum. However, it is conceptionally less known to what extent the hot and dense plasma environment influences the DM gauge-boson exchange during the freeze-out process. We developed a comprehensive ab initio derivation of the Sommerfeld effect at finite temperature in the framework of non-equilibrium quantum field theory. After sketching this novel derivation, I discuss various approximation and solution strategies of this most general result. In certain limits we recover among the standard vacuum case also the equilibrium case, where the finite temperature corrections we obtain are compatible with the results recently derived from linear response theory estimates (see M. Laine et. al. in 2017). I briefly discuss the limitation of the latter approach and finally present phenomenological consequences and the physical origin of the leading finite temperature corrections to the Sommerfeld effect.

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