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Kinetic/chemical Equilibration of Heavy DM Particles in Expanding Universe via Langevin equation simulation

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Recently, a question about how far chemical freeze-out of heavy Dark Matter (DM) particles can be pushed down in temperature has been raised. In this case, kinetic equilibration of heavy DM through elastic collisions with strongly interacting Standard Model particles such as quarks and gluons at the temperature of a few GeV could potentially complicate the consideration. Thus, we study kinetic equilibration of heavy dark matter particles in non-perturbative regime using Langevin equation simulation. We note that the kinetic equilibration of slowly moving DM particle in the thermal bath of SM particles is analogous to kinetic equilibration of heavy quarks in Quark-Gluon Plasma and that Langevin equation method is superior to a standard formulation based on Boltzmann equation because Langevin simulation allows systematic study even in non-perturbative regime. As a concrete numerical example, we consider a scalar singlet DM particle interacting with quarks and gluons and find that the momentum distribution of DM particle retains the Gaussian form although the spectrum becomes red-tilted and its overall effect on the chemical equilibration of DM particles to be {\cal O} (20) %.

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