Contribution ID: **55** Type: **Talk**

Thermal correction to Dark matter annihilation processes at NLO

Wednesday, 20 December 2023 15:30 (15 minutes)

In a scattering process in a thermal plasma, thermal fluctuation alongside with quantum fluctuation affects the annihilation cross section of particles. This is important in the context to dark matter annihilation cross section since the relic densities are now being more precisely measured. We investigate the effect of thermal fluctuation on the annihilation cross section of a $SU(2) \times U(1)$ singlet, bino-like thermal dark matter particle χ of mass $m_\chi \sim \mathcal{O}(0.1 - 1\, TeV)$, annihilating to standard model fermion $(f^0, f^-)^T$ through scalar channel (ϕ^+, ϕ^0) of mass $m_\phi > m_\chi$, in an MSSM inspired BSM theory with Yukawa interaction $(\mathcal{L} \supset \lambda\lambda\overline{\chi}P_L f^-\phi^+ + h.c.)$, utilizing generalized Grammer and Yennie technique in thermal field theory in real-time formalism. We find the IR divergences cancel at NLO order between real and virtual photon corrections. In particular, we find the finite reminder shows a quadratic dependence of the scattering cross section on temperature $\sigma_T \propto T^2$, for the process $\chi\bar{\chi} \to f\bar{f}$ at NLO, on considering various kinematically allowed cases, in the limit where the heavy scalars are assumed to be non-dynamical. Contribution arises from both the cases, with photon or fermion to be thermal, both giving rise to T^2 terms.

Keywords : Dark Matter, IR divergences, Thermal Field Theory

Reference publication/preprint

Designation

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Session Classification: Parallel: DM + neutrino