Contribution ID: **66** Type: **Young Scientist Forum**

Dissipative Losses in Self-Interacting Dark Matter Collisions

Friday, April 21, 2017 7:30 PM (8 minutes)

Dark matter self-interactions are frequently used in the explanation of small structure problems in the universe. Depending on the model and strength of the interactions they can have important implications on the formation of structures, from dwarf galaxies to large galaxy clusters. Using four generic dark matter toy models, we present the effects of inelastic processes (i.e. dark bremsstrahlung) in dark matter collisions on structure formation in the universe. For that purpose, we compare the cooling time due to dark bremsstrahlung of a gas of dark matter particles in a non-relativistic and non-degenerate limit to the elastic scattering time scale, the Hubble time and the gravitational timescale. Our models show that the energy loss in dark matter collisions with dark dipole radiation can have an influence on structure formation for much smaller dark matter densities than quadrupole radiation and is - assuming very light (eV range) mediators - important for dark matter densities > 1 GeV/cm3. However, in regions of the universe where the dark matter density is a few orders of magnitude higher, even dark bremsstrahlung in systems with vanishing dipole moment can influence structure formation while satisfying observational constraints. We also find that the energy loss rate due to dark bremsstrahlung gets enhanced in dark matter models with an attractive self-interaction, increasing the parameter space where effects on structure formation are important.

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Session Classification: YSF

Track Classification: Dark Matter