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Thermal corrections to dark matter annihilation processes

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The dark matter (DM) problem has been investigated and discussed in many papers, within the regime of quantum field theories at zero temperature. Experimental evidence of DM from various experiments such as Planck, limits the relic abundance of Dark Matter, $\Omega_{DM}h^2 \sim 0.120 \pm 0.001$, with data from both Planck and WMAP.
The precision on this result is expected to improve further. Hence it becomes important to calculate DM annihilation cross sections to better precision. In particular, thermal contributions to the annihilation cross section can become significant.

It therefore becomes important to investigate the problem using thermal field theory techniques. Such theories of bino-like DM interacting with a heat bath of fermions, scalars and photons, have already been shown to be infra-red (IR) finite to all orders in perturbation theory [1] .
We therefore use these theories to find the temperature dependence of the DM annihilation cross sections.

An MSSM-inspired model [2], with a bino-like Dark Matter candidate χ is used for investigating the temperature dependence of the cross section for the process $\chi\chi \to f\overline{f}$. Here f's are the Standard Model fermions and ϕ's are charged scalar doublets.

We have computed the 1-loop higher order thermal corrections to this scattering cross section. We find terms with T^2 dependence, at order α, where T is the temperature of the heat
bath. The calculations are performed within the approximation where the scalar mass is large, $m_\phi > m_\chi$, much larger than the fermion mass. The thermal region of interest in calculating the relic densities is in the region $m_\chi/T \sim 20$, at freeze-out, after the electro-weak phase transition. A novel feature of the calculation is its use of the Grammer-Yennie technique [3] to isolate the IR finite components.

Keywords : Dark Matter, Thermal field theory, IR divergences

References :

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