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Non-adiabatic evolution of a dark sector in the presence of $U(1)_{L_\mu - L_\tau}$ gauge symmetry

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In a secluded dark sector scenario, the connection between the visible and the dark sector can be established through a portal coupling and its presence opens up the possibility of non-adiabatic evolution of the dark sector. Here, we have considered a $U(1)_{L_\mu - L_\tau} \otimes U(1)_X$ extension of the standard model (SM) to study the evolution of a decoupled dark sector in a radiation-dominated Universe. Depending on the values of the portal coupling (ϵ), dark sector gauge coupling (g_X), the mass of the dark matter (m_χ), and the mass of the dark vector boson ($m_{Z'}$), we study the temperature evolution of the dark sector as well as the various non-equilibrium stages of the dark sector in detail. Furthermore, we have also investigated the constraints on the model parameters from various laboratory and astrophysical searches. We have found that for $m_{Z'} < 100\mathrm{MeV}$, parameter space for the non-adiabatic evolution of the dark sector is significantly constrained from the observations of beam dump experiments, stellar cooling etc. The bounds from direct detection, and self-interaction of dark matter (SIDM) for the mass ratio $r \equiv m_\chi / m_{Z'} = 10^{-3}$ are consistent with the relic density satisfied region and these bounds will be more relaxed for larger values of r. However the constraints from the measurement of diffuse γ-ray background flux and cosmic microwave background (CMB) anisotropy are strongest for $r = 10^{-1}$ and for smaller values of r, they are not significant.

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Dark Matter Physics

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