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Cannibal dark matter decoupled from standard model: cosmological constraints

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Abstract : We study the cosmology of an internally thermalized dark matter (DM), which is either coupled only gravitationally with the standard model (SM) sector, or may have a very feeble non-gravitational interaction that does not thermalize the two sectors. In the former scenario, the DM may undergo number-changing self-scatterings in the early Universe, eventually freezing out to the observed DM abundance. If these reactions, such as a 3 to 2 process, take place when the DM is non-relativistic, DM cannibalizes itself to cool much slower than standard non-relativistic matter during the cannibal phase. We find that depending upon the DM self-couplings, a scalar cannibal DM with mass in the range of around 80 eV to 700 TeV can make up the observed DM density and satisfy all the constraints, when the initial DM temperature (T_DM) is lower than the SM one (T_SM), with T_SM/9100<T_DM<T_SM/1.1. In the latter scenario, we further investigate the origin of the initial DM energy density in the Universe at the post-inflationary reheating epoch, and determine to what extent inflaton-mediated DM-SM scattering reactions can modify the temperature of the DM, thereby changing the initial conditions of DM temperature evolution during its non-relativistic phase. In each scenario, we evaluate the cosmological constraints from the cosmic-microwave background power spectrum, the big-bang nucleosynthesis limits on the relativistic degrees of freedom, the Lyman-alpha limits on the DM free-streaming length, and the Bullet Cluster constraints on DM elastic self-scatterings.

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