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CMB signature of non-thermal Dark Matter

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Abstract-The basic idea of this work is to achieve the observed relic density of a non-thermal dark matter(DM) and its connection with Cosmic Microwave Background (CMB) via additional relativistic degrees of freedom which are simultaneously generated during the period TBBN to TCMB from a long-lived dark sector particle.. To realize this phenomena we minimally extend the type-I seesaw scenario with a Dirac fermion singlet(χ) and a complex scalar singlet (φ) which transform non-trivially under an unbroken symmetry ⊠3. χ being the lightest particle in the dark sector acts as a stable dark matter candidate while the next to lightest state φ operates like a long lived dark scalar particle. The initial density of φ can be thermally produced through either self-interacting number changing processes ($3\varphi \longrightarrow 2\varphi$) within dark sector or the standard annihilation to SM particles ($2\varphi \longrightarrow 2$ SM). The late time (after neutrino decoupling) non-thermal decay of φ can produce dark matter in association with active neutrinos. The presence of extra relativistic neutrino degrees of freedom at the time of CMB can have a significant impact on ΔNeff. Thus the precise measurement of ΔNeff by current PLANCK 2018 collaboration and future experiments like SPT-3G and CMB-S4 can indirectly probe this non-thermal dark matter scenario which is otherwise completely secluded due to its tiny coupling with the standard model.

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