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From warm dark matter to dark radiation: General cosmological constraints on a second dark component in the Universe

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A mixed dark matter model consists of a cold dark matter (CDM) fraction and a fraction given by another dark component (non-cold). The free-streaming length increases with the velocity of the dark matter particle, varying from a scale value of Mpc for a warm dark matter component up to the size of Universe for a relativistic species that we label as dark radiation.
We study these models varying the mass of the non-cold dark matter particle and the fraction of total energy density that it brings. We perform our analysis by using the combination of recent Planck Cosmic Microwave Background (CMB) measurements (Planck TT+lowP dataset) to put bounds on the masses the non-cold dark matter species as well as on the amount of the additional energy density of relativistic species. Considering the matter power spectrum, used also to calculate the amount of the dwarf galaxies satellites, we can explore which components contribute to the total energy density and we can put limits either on the fraction of this second component with respect to the total dark matter, or on its mass.
A particle associated to this second component of dark matter with a larger free-streaming length, indeed, could affect the matter power spectrum on the smallest scales, improving the compatibility with the observations of the local Universe.
We finally analyse how the variation of the free-streaming length could shed light on the different (non-cold) dark matter species for all ranges of masses.

Summary

In this work we explore the phenomenology of a mixed dark matter (DM) model that consists of a cold DM and a general non-cold component. The non-cold component can act as either warm DM, hot DM or dark radiation (DR), depending on the characterizing free-streaming length that varies in our analysis between Mpc and Gpc scales. We perform a Bayesian analysis based on a combination of recent Planck observations of the cosmic microwave background, the observation of dwarf spheroidal galaxies and galaxy distributions. We put constraints on the energy density of the non-cold component as function of the free-streaming length and discuss future observational prospects.

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