

New opportunities for axion dark matter searches in nonstandard cosmological models

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Introduction

The axion is a by-product of an elegant solution of the strong CP problem of the QCD sector [1]. Interestingly, the same mechanism that solves the strong CP problem, leads to an efficient mechanism of nonthermal production (the so-called misalignment mechanism), in which a cold population fills the universe, making the axion a cold dark matter (CDM) candidate [2,3].

Since no DM axion signal has been found so far, in this work we propose an alternative to expand the mass range in which the axion can explain CDM abundance by considering a non-standard cosmological history (NSC). In this way, entropy is injected into the thermal bath, diluting the energy density of the axion.

Axion CDM in NSC

We consider a new field ϕ with a general equation of state, $\omega = p_\phi/\rho_\phi$, that during a certain period dominates the energy density of the universe and then the field decays into SM radiation R , with a total decay rate Γ_ϕ . The Boltzmann equations that govern the evolution of the energy density of ϕ and the SM entropy density s are

$$\frac{d\rho_\phi}{dt} + 3(1 + \omega) H \rho_\phi = -\Gamma_\phi \rho_\phi, \quad \frac{ds}{dt} + 3 H s = +\frac{\Gamma_\phi}{T} \rho_\phi, \quad (1)$$

such that expansion of the universe has a new contribution by ϕ , $H = \sqrt{(\rho_\phi + \rho_R)/3M_P^2}$, generating an impact on the dynamics of the axion field θ , which is given by

$$\ddot{\theta} + 3H \dot{\theta} + m_a^2 \sin \theta = 0. \quad (2)$$

We will comment on the masses to which we can extend the axion parameter space depending on the equation of state of the field ϕ .

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Referencias

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