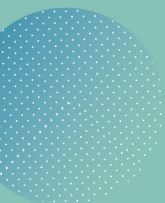




INSTITUTO DE FÍSICA
DE PARTÍCULAS Y DEL COSMOS

IPARCOS



Preprint Series in Particles and Cosmos Physics

n° IPARCOS-UCM-26-053

Breaking the axion abundance–isocurvature relation: Scale invariance and high-scale inflation

by M. De Angelis and J. Rubio

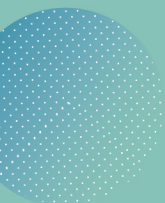
October 2026

Plaza de las Ciencias, 1 28040 Madrid, Spain

www.ucm.es/iparcos/



UNIVERSIDAD
COMPLUTENSE
MADRID



Abstract

A QCD axion accounting for dark matter through pre-inflationary misalignment is strongly constrained by CMB isocurvature bounds, which place the classic axion window in tension with highscale inflation. The tension arises because the same decay constant controls both the relic abundance and the primordial axion fluctuations. We show how this link can be broken in a broad class of scaleinvariant models, without introducing any dimensionful parameter into the classical action. Rather than imposing a fixed Peccei-Quinn scale, the axion's kinetic normalisation is set by a dynamical field ratio. The resulting field-space metric controls the abundance through its value today and the primordial fluctuations through its value at horizon crossing. A sufficiently large metric during inflation suppresses isocurvature, allowing high-scale inflation in the classic axion window with an untuned misalignment angle and sub-Planckian decay constants. The exact scale and Peccei-Quinn symmetries also enforce a non-turning inflationary attractor, conserving the super-Hubble curvature perturbation and preserving the single-field adiabatic spectrum. We realise the mechanism in the Higgs-Dilaton model by deforming the Peccei-Quinn kinetic term. The same deformation turns the inflaton sector into an α -attractor pinned near the Starobinsky point. This explicit realisation has a super-Planckian present decay constant and therefore reopens the anthropic window at high inflationary scales, with an ultralight QCD axion constrained by black-hole superradiance.

