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Coherent Enhancement of the Axion Decay Constant in Inflation and the Weak Gravity Conjecture

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Models of axion inflation based on a single cosine potential require the axion decay constant to be super-Planckian in size. However, a super-Planckian axion decay constant is disfavored in quantum gravity and in strings, and by the weak gravity conjecture. Here we propose a coherent enhancement mechanism which can produce an effective axion decay constant which is super Planckian even if the true decay constant is sub Planckian. We discuss the utility of this mechanism for a variety of axion potentials originating in supersymmetry, supergravity, and strings. The coherent enhancement mechanism allows one to reduce an inflation model with an arbitrary potential to an effective model of natural inflation, i.e. with a single cosine, by expanding the potential near an inflationary point, and matching the expansion coefficients to those of natural inflation. We demonstrate that this approach can predict the number of e-foldings in a given inflation model without the need for numerical simulation. Further we show that the effective decay constant f_e can be directly related to the spectral indices so that $f_e = M_{\rm P}/\sqrt{1-n_s-r/4}$ where n_s is the spectral index for curvature perturbations and r is the ratio of the power spectrum of tensor perturbations and curvature perturbations. The current data on n_s and r constrains the effective axion decay constant so that $4.9 \leq f_e/M_{\rm P} \leq 10.0$ at 95% CL. Thus an important result of the analysis is that the effective axion decay constant has an upper limit of $\sim 10 M_{\rm P}$ in units of Planck mass in axion cosmology for any potential-based model which produces successful inflation. The coherent enhancement mechanism for the generation of an effective $f_e > M_{\rm P}$ while the true axion decay constant $f < M_{\rm P}$ is discussed. We illustrate the coherent enhancement in globally supersymmetric models and supergravity models. We also show that f_e based on inflation dynamics can be defined for non-potential-based models, and consider a Dirac-Born-Infeld model as an example. In each case, all the moduli are stabilized and the inflationary model consistent with astrophysical observations with $f_e > M_{\rm P}$ and the true axion decay constant $f < M_{\rm P}$ consistent with the weak gravity conjecture.

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