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Stochastic Axion-like Curvaton: Non-Gaussianity and Primordial Black Holes Without Large Power Spectrum

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We discuss a mechanism of primordial black hole (PBH) formation that does not require specific features in the inflationary potential, revisiting previous literature. In this mechanism, a light spectator field evolves stochastically during inflation and remains subdominant during the post-inflationary era. Even though the curvature power spectrum stays small at all scales, rare perturbations of the field probe a local maximum in its potential, leading to non-Gaussian tails in the distribution of curvature fluctuations, and to copious PBH production. For a concrete axion-like particle (ALP) scenario we analytically determine the distribution of the compaction function for perturbations, showing that it is characterized by a heavy tail, which produces an extended PBH mass distribution. We find the ALP mass and decay constant to be correlated with the PBH mass, for instance, an ALP with a mass ma=5.4×1014 eV and a decay constant fa=4.6×10−5Mpl can lead to PBHs of mass MPBH=1021 g as the entire dark matter (DM) of the universe, and is testable in future PBH observations via lensing in the NGRST and mergers detectable in the LISA and ET Gravitational Waves (GW) detectors. We then extend our analysis to mixed ALP and PBH dark matter and Higgs-like spectator fields. We find that PBHs cluster strongly over all cosmological scales, clashing with CMB isocurvature bounds. We argue that this problem is shared by all PBH production from inflationary models that depend solely on large non-Gaussianity without a peak in the curvature power spectrum and discuss possible remedies.

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