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Superhorizon curvature perturbations in hybrid inflation

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We utilize the δN formalism within a parameter space formed by the e-folding number N and its transverse subspace to explicitly account for the geometry of the final hypersurface in multi-field inflation. Applying this framework to hybrid inflation, we identify an enhancement mechanism of the curvature perturbation driven by the growing isocurvature perturbation due to the tachyonic instability of the waterfall field. This amplification occurs during the trajectory's turn in field space, a process qualitatively distinct from the background deceleration in single-field non-attractor models such as ultra-slow-roll. The resulting power spectrum features a broad peak with a characteristic k^3 infrared growth and a ultraviolet spectral tilt that uniquely determines the nonlinear parameter $f_{\rm NL}$ of a logarithmic non-Gaussianity, all of which are primarily governed by the waterfall dynamics. The enhanced curvature perturbation can simultaneously account for primordial black hole dark matter and a stochastic gravitational wave background detectable by LISA, Taiji, and TianQin.

Presenter(s) : Mr XIONG, Anxianyi (ITP-CAS)

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