Power spectrum of scalar and tensor perturbations in Cuscuton bounce

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Introduction

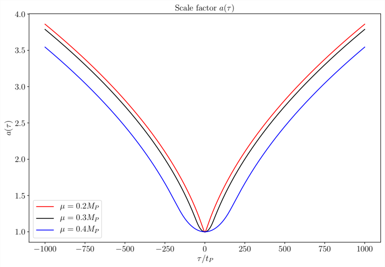
- Inflation is the current paradigm for the very early universe, but are there others?
- Bounce models generally violate the null energy condition (NEC) which can lead to instabilities or ghosts.
- One work-around to these problems is a Cuscuton bounce (Boruah, Kim, Geshnizjani 2017, Boruah et al. 2018) generated by Cuscuton gravity.
- This talk is based on [arXiv:2010.06645] (Kim, Geshnizjani 2020) which shows stability for solutions throughout the bounce, as well as consideration of various initial conditions.

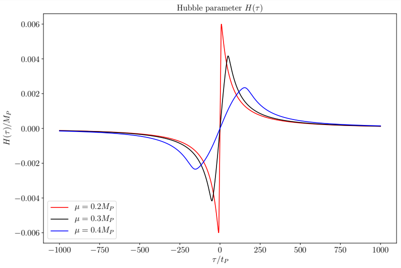
Single-field Cuscuton bounce

The action is given by:

$$S = \int d^4x\sqrt{-g}\left[\frac{M_P^2}{2}R - \frac{1}{2}D_\mu\pi D^\mu\pi - \mu^2\sqrt{-D_\mu\varphi D^\mu\varphi} - V(\varphi)\right].$$

where φ is the Cuscuton field and π is a canonical scalar field. φ has no dynamical degrees of freedom! No instabilities or ghosts!

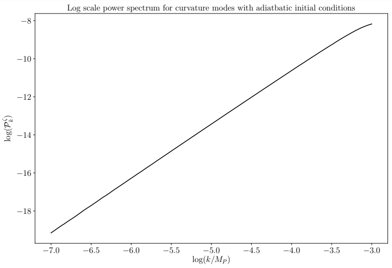


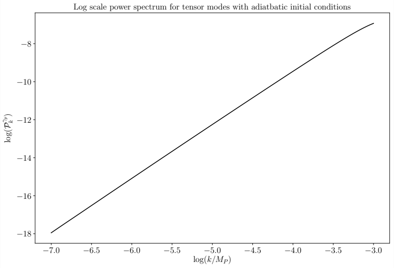


Power spectrum for single-field Cuscuton bounce

Perturbation theory – assuming **adiabatic vacuum initial conditions**, both spectra are strongly blue.

$$\mathcal{P}_k^{\zeta_k}(\tau_f) = \frac{k^3}{2\pi^2 M_p^2}\frac{|v_k(\tau_f)|^2}{z^2(\tau_f)}, \quad \mathcal{P}_k^{\gamma_p}(\tau_f) = \frac{k^3}{2\pi^2}\frac{|2v_p(k,\tau_f)|^2}{M_P^2\ a^2(\tau_f)}$$





Implementation of the entropic mechanism

Add another field χ, action becomes

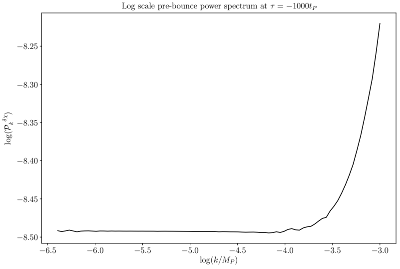
$$S = \int d^4x\sqrt{-g}\left[\frac{1}{2}R - \frac{1}{2}D_\mu\pi D^\mu\pi - \frac{1}{2}F(\dot{\pi})D_\mu\chi D^\mu\chi - \mu^2\sqrt{-D_\mu\varphi D^\mu\varphi} - V(\varphi)\right],$$

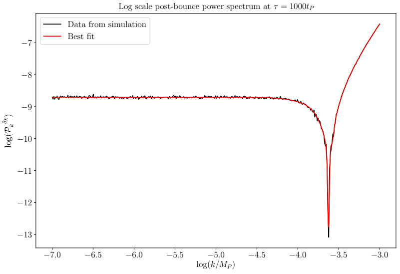
The coupling function is taken to be $F(\dot{\pi}) = \rho_m/(\Lambda M_P^2)$ where Λ is a free parameter. Perturbation theory gives:

$$u_k'' + \left(k^2 - \frac{q''}{q}\right)u_k = 0, \quad \mathcal{P}_k^{\delta\chi}(\tau_f) = \frac{k^3}{2\pi^2}\frac{|u_k(\tau_f)|^2}{M_p^2 q(\tau_f)^2}.$$

Power spectrum for two-field Cuscuton bounce

This results in a scale-invariant power spectra both before and after the bounce.





Summary

- Scale-invariance in single field Cuscuton bounce is hard
- However, adding another specatator field can produce scale-invariant entropy perturbations.
- Future work:
  - Converting entropy perturbations into adiabatic ones
  - How do we get a tilt in our power spectrum?
  - Other observational features of Cuscuton bounce
- Please see poster [KIAS Poster] or paper [arXiv:2010.06645] for more details.
- Thank you!