Probing the Big Bounce Scenario with Cuscuton

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Introduction

- Cosmological Perturbation Theory
- Scale-invariant power spectrum from adiabatic vacuum fluctuation

Observational Data

- Accelerated expansion (Inflation)
- Or the issues of
  - Null Energy Condition ($(\rho + P) < 0$)
  - Superluminal signal propagation
  - Sub-Planckian energy densities

Cuscuton: Theory for modifying gravity

- Causal Scalar Field Theory with Non-dynamical Degree of Freedom $\Rightarrow$ Cuscuton Field[1]

$$\mathcal{L}_{cuscuton} = \pm\mu^2\sqrt{X} - V(\varphi), \quad \text{where } X = g^{\alpha\beta}\nabla_\alpha\varphi\nabla_\beta\varphi \tag{1}$$

- In the presence of another scalar field π with a canonical kinetic term,

$$\dot{H} = \mp\mu^2 a \mid \dot{\varphi}_0 \mid -\frac{1}{2}\dot{\pi}_0^2 \tag{2}$$

[1] N. Afshordi, D. Chung, G. Geshnizjani(2007)

Conclusion

The action to second order in perturbed quantities

$$\delta S_2 = \int d^3\mathbf{k} d\tau \; z(\mathbf{k},\tau)^2 \left[\zeta_k'^2 - c_s(\mathbf{k},\tau)^2 \; \mathbf{k}^2 \zeta_k^2 \right] \tag{3}$$

In the UV Limit where $\mathbf{k} \to \infty$

$$\delta S_2 = \int d\tau d^3\mathbf{k} \left\{ a^2 \frac{\pi_0'^2}{2\mathcal{H}^2} \left[\zeta_{\mathbf{k}}'^2 - \mathbf{k}^2 \zeta_{\mathbf{k}}^2 \right] \right\} \tag{4}$$