Local Features in the CMB Power Spectrum

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In this work we study two stage models of inflation and the generation of features in power spectrum. We first consider inflationary models with two stages. Here we consider chaotic potential and symmetry breaking inflation. Then we compare a general class of two stages models that separated with an intermediate phase with equation of state ω with CMB data and we show that these models are more consistent with data rather than LCDM model.

Introduction

Inflation has proven to be the most efficient mechanism to overcome difficulties such as the horizon and the flatness problems that plague the standard, hot, big bang cosmological model. Importantly, in addition to resolving such issues, inflation successfully generates primordial fluctuations which seed the formation of structures.

Although, a nearly scale invariant power spectrum predicted by slow roll inflation, along with the background ΛCDM model, matches the angular spectrum from the CMB observations quite well, there exists a few outliers (notably, near the multipole moments of ℓ = 2, 22 and 40) in WMAP data. Interestingly, model independent reconstruction of the primordial spectrum from the observed pattern of the CMB anisotropies seem to suggest the possible presence of specific features in the spectrum.

As is well known, a featureless, scale invariant perturbation spectrum can be produced by a suitably long epoch of slow roll inflation. However, generating features in the scalar power spectrum require one or more periods of deviation from slow roll inflation. For instance, it is found that one needs a large deviation from slow roll in order to produce a sharp drop in power, say, so as to fit the low quadrupole. The larger the deviation from slow roll, the sharper the drop is found to be and, in fact, a brief departure from inflation-which leads to a sharp rise in power and a couple of oscillations before the spectrum turns nearly scale invariant– has been found to provide a good fit to the data at the lower multipoles.

Slow-roll inflationary models generically produce a nearly scale-invariant primordial power spectrum of curvature perturbations. Hence, measuring deviations from scale invariance of the spectrum is a critical test of cosmological inflation. For a power-law parameterization of the spectrum motivated by inflationary models with featureless inflation potentials, the exact scale-invariant spectrum is excluded at more than 99% confidence level by the 7-year WMAP data.

Models and Methodology

Some inflationary models with a locally featured potential can generalized local feature in the power spectrum. The feature of potential should be fine tuned at the value of inflaton field when the modes corresponding to our large scale universe exist the horizon.

We used Maximium Likelihood analysis to find observational constraints from CMB data for following models and also we computed the power spectra of Cosmic Microwave Background temperature anisotropies for such models.

Chotic potential model

In this section we consider an inflationary model with Chaotic inflaton potential which leads to following spectral index:

$$n_s - 1 \approx \frac{-2}{N(k_0)} + \frac{1}{N(k_0)} \frac{\alpha e^{4N(k_0)} \left(\frac{k}{k_p}\right)^4}{1 - \alpha\left(1 - e^{4N(k_0)}\left(\frac{k}{k_0}\right)^4\right)}$$

$$n_s - 1 \simeq n_s^{(0)} - 1 + \Delta n_s$$

$$\mathcal{P}_\zeta = A_s k^{n_s^{(0)} - 1 + \Delta n_s}$$

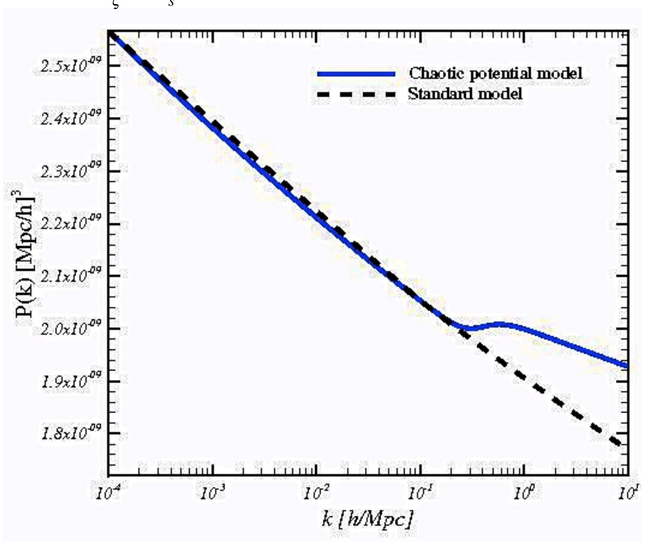

Figure1: Primordial power spectrum of Chaotic potential

In Fig.1 we showed the primordial power spectrum of this model which has deviation from standard model of inflation.

CMB power spectrum of anisotropies

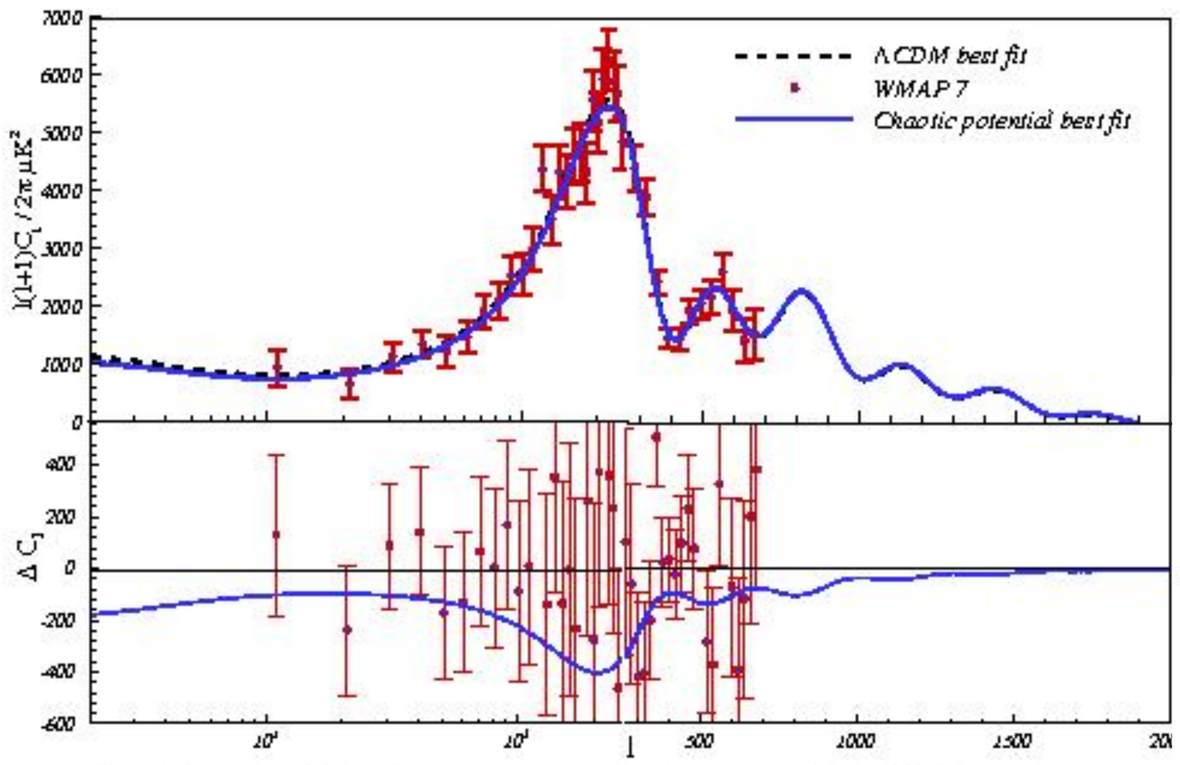

Figure4: Comparing CMB best fit power spectrums of Chaotic potential model with WMAP 7 years data.

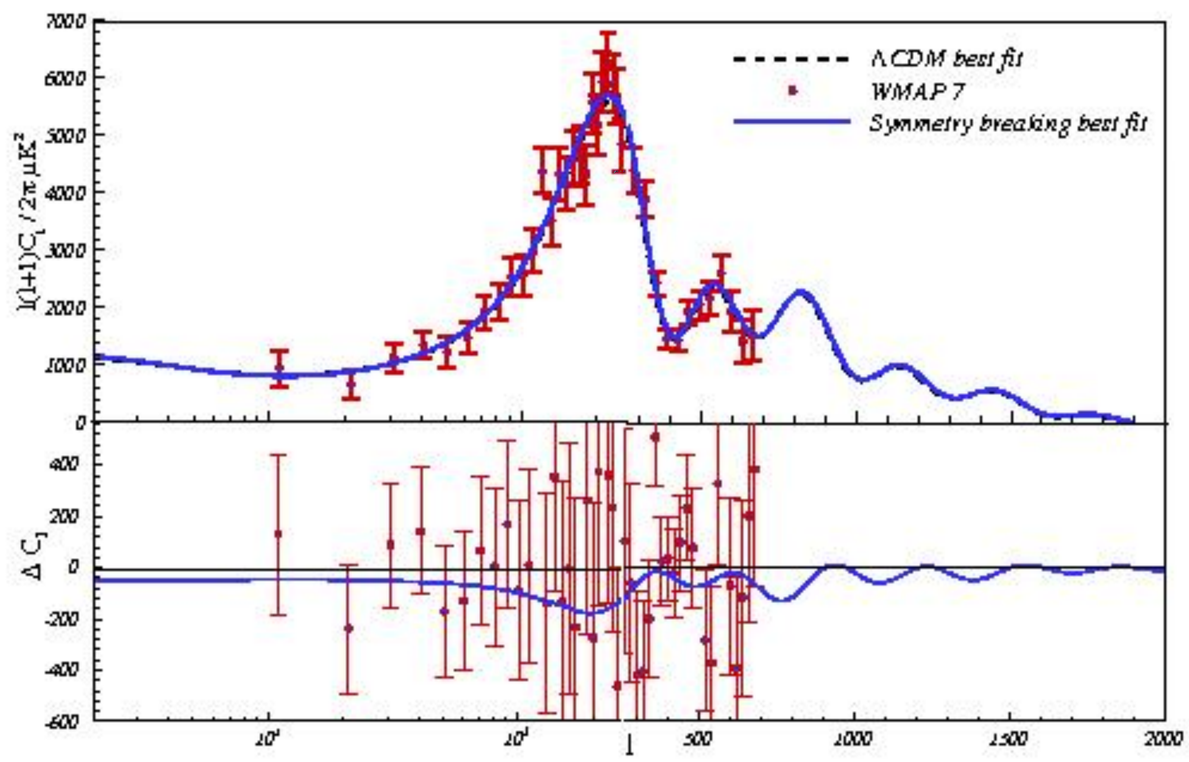

Figure5: Comparing CMB best fit power spectrums of Symmetry breaking model model with WMAP 7 years data.

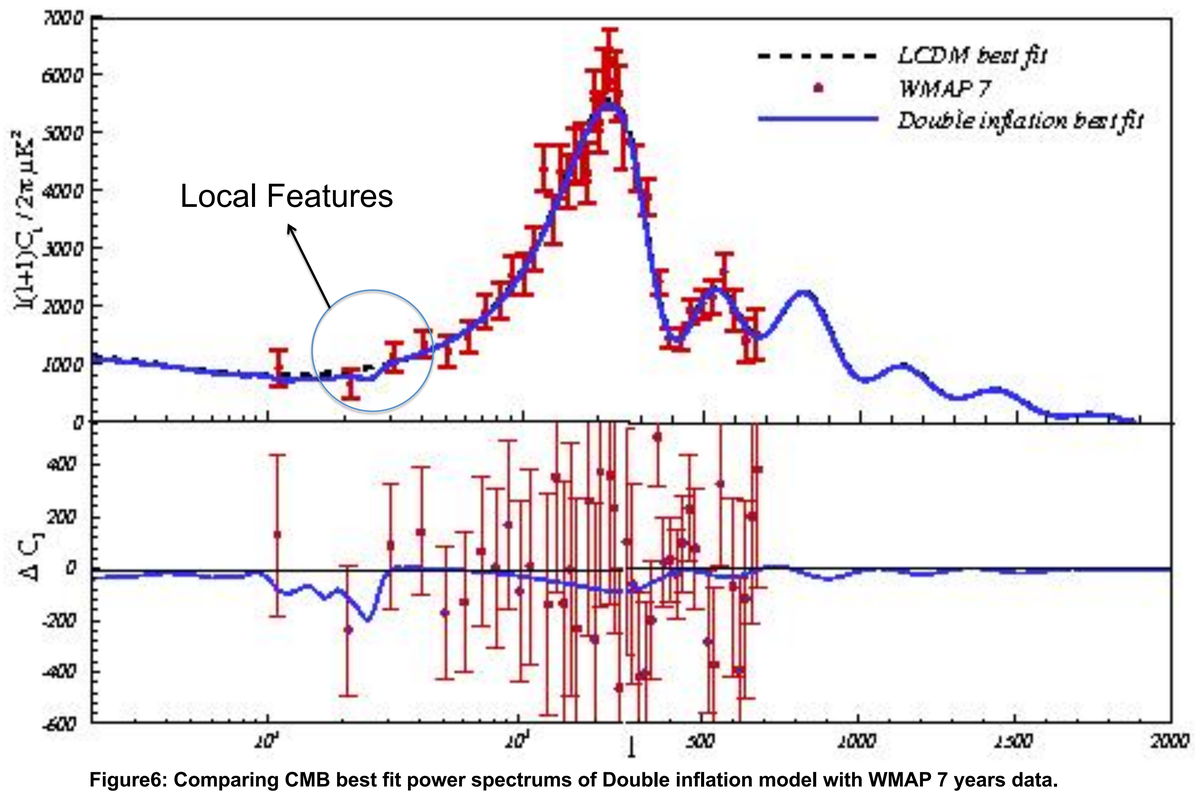

Figure6: Comparing CMB best fit power spectrums of Double inflation model with WMAP 7 years data.

Symmetry breaking model

In this new class of approaches, we consider gauge vector fields with a coupling to the scalar inflaton field. The inflaton trajectory takes a glitch on the background due to the interaction with gauge fields. As will be shown this glitch leads to generation of a feature in the power spectrum.

$$n_s - 1 \approx \frac{-2}{p_c} + \frac{2p}{3} \frac{\alpha\left(\frac{k}{k_p}\right)^{\frac{4(p-p_c)}{p_c}}}{1 + \alpha p p_c \left(\frac{k}{k_p}\right)^{\frac{4(p-p_c)}{p_c}}}$$

Figure2: Primordial power spectrum of Symmetry breaking model

Double inflation model

In these models a second stage in inflation follows the first one. The inflationary phases may be separated by a matter or radiation phase. It can also be assumed that large scales exist the horizon during first phase or second phase.

The primordial power spectrum of this model can be written in this form:

$$\mathcal{P}_\zeta^{\Delta k} = \mathcal{P}_\zeta^{(0)} \frac{\Gamma^2(2 - \frac{n_s}{2})}{2\sqrt{2}\pi} (-k\eta_c)^{n_s - 3} [1 + \sin(k\eta_c + \pi\nu)]$$

$$n_s = 4 - 2\nu$$

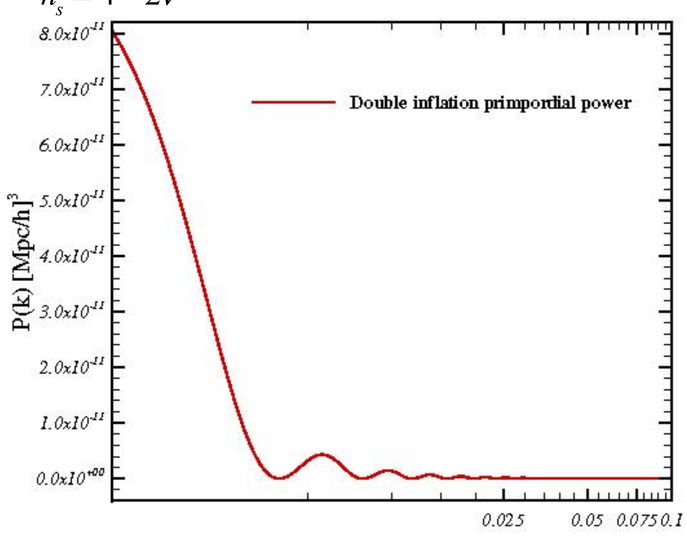

Figure3: Primordial power spectrum of Double inflation model

Conclusion

In this work we were searching for some models which produce local feature seen in the WMAP data and power spectrum of CMB observations. We examined three type of inflationary models and we show that some models don't lead to such local feature in CMB power spectrum but some models like double inflation models could produce local feature in power spectrum.

References

[1] J. A. Adams, B. Cresswell and R. Easther, "In ationary perturbations from a potential with a step," Phys. Rev. D **64**, 123514 (2001) [astro-ph/0102236].

[2] A. A. Abolhasani, H. Firouzjahi, S. Khosravi and M. Sasaki, "Local Features with Large Spiky non-Gaussianities during In ation," arXiv:1204.3722 [astro-ph.CO].

[3] P. Adshead, C. Dvorkin, W. Hu and E. A. Lim, "Non-Gaussianity from Step Features in the Inflationary Potential," Phys. Rev. D **85**, 023531 (2012)