The lattice simulation of the geometrical destabilization of inflation

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Plan of presentation

- Introduction
- The mechanism of the geometrical destabilization of inflation
- Approximate analysis and the possible effects of geometrical destabilization on the inflationary trajectory
- The results of the lattice simulations of the geometrical destabilization of inflation
- Summary

Presentation Outline

- Cosmological inflation - a natural ingredient of the standard big bang cosmological model
- However:
  - Remains a very general theory (many models of inflation consistent with data)
  - Huge theoretical uncertainty of the inflationary predictions due to the lack of precise knowledge about reheating
  - Possible strong impact of the secondary fields on the inflationary trajectory affecting the predictions drawn from the considered models

Presentation Outline

- Geometrical destabilization - the destabilization of noninflationary scalar degrees of freedom due to the negative curvature of fields-space manifold
- The fields-space of supergravity originated models of inflation is very often equipped with negative curvature
- The negative curvature naturally appears in EFT, when to the inflaton lagrangian we add the second scalar field lagrangian
- The destabilization of the auxiliary fields can strongly affect the inflationary trajectory

Renaux-Petel, Turzyński
arXiv:1510.01281

Simple realization of GD for Starobinsky model of inflation

- To the inflaton single-field lagrangian for Starobinsky model:

$$L_\phi = -\frac{1}{2}(\partial\phi)^2 - V(\phi) \quad \text{where} \quad V(\phi) = M^4[1 - \exp(-\sqrt{2/3}\phi/M_P)]^2$$

- we add the second field lagrangian:

$$L_\chi = -\frac{1}{2}(\partial\chi)^2 - \frac{1}{2}m_h^2\chi^2$$

- In the EFT approach the additional term naturally emerges:

$$\Delta L = -(\partial\phi)^2\chi^2/M_{\mathrm{np}}^2 \quad \Longrightarrow \quad R_{fs}|_{\chi=0} = -\frac{4}{M_{\mathrm{np}}^2}$$

$$\Longrightarrow \quad \Delta m_\chi^2 = -4\epsilon H^2\left(\frac{M_P}{M_{\mathrm{np}}}\right)^2 \quad \text{for} \quad \epsilon H^2 M_P^2 = \frac{1}{2}\dot{\phi}^2$$

- It destabilizes the initially stable trajectory $\chi = 0$

Simulations setup

- The simulations were performed for:

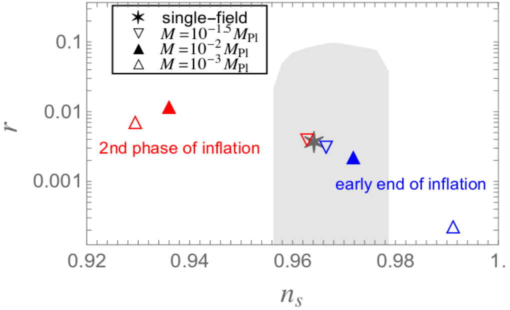
$$m_h^2 = 10H_c^2 \quad \text{and} \quad M_{\rm np} = 10^{-1.5} M_P \quad \text{or} \quad M_{\rm np} = 10^{-2} M_P$$

- H_c - the value of Hubble constant at the point, where the mass $m_{\chi,eff}$ becomes negative

- We start the simulations where the mass $m_{\chi,eff}$ becomes negative (around $\Delta N = 4.5$ and $\Delta N = 15.1$ e-folds before the end of single-field inflation for $M_{\rm np} = 10^{-1.5} M_P$ and $M_{\rm np} = 10^{-2} M_P$ respectively)

Presentation Outline

Possible consequences of Geometrical Destabilization



Renaux-Petel, Turzyński arXiv:1510.01281

Grocholski et al. arXiv:1901.10468

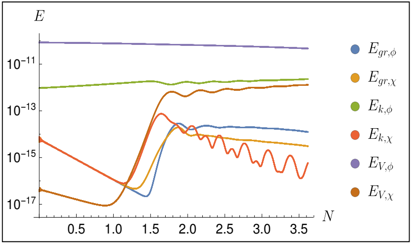
Results of two approximate approaches:

- The inflation ends abruptly at the point, where the mass of the second field vanishes
- The homogeneous value of field χ is assumed to be equal $H/2\pi$ at the point, where the mass of the second field vanishes

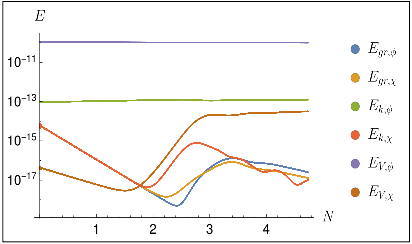
Presentation Outline

Plots of different energy density components

$M_{\text{np}} = 10^{-1.5} M_P$



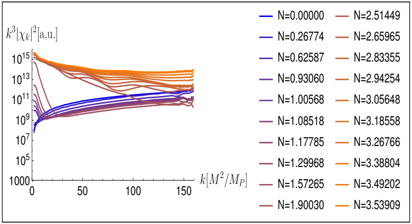
$M_{\text{np}} = 10^{-2} M_P$



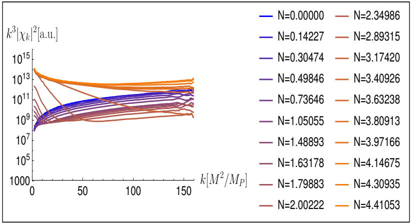
- Geometrical destabilization increases the fraction of χ-energy density components
- At the end of simulations the gradient energy density components decrease suggesting that the inflationary trajectory falls into the new homogeneous attractor

The power spectrum of field χ

$M_{\rm np} = 10^{-1.5} M_P$

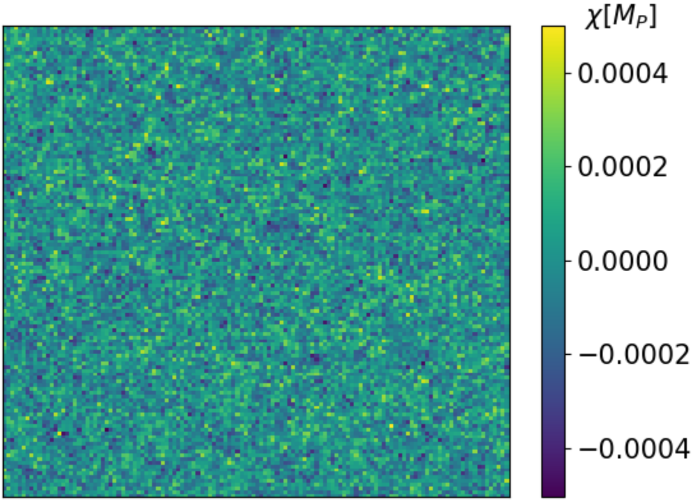


$M_{\rm np} = 10^{-2} M_P$

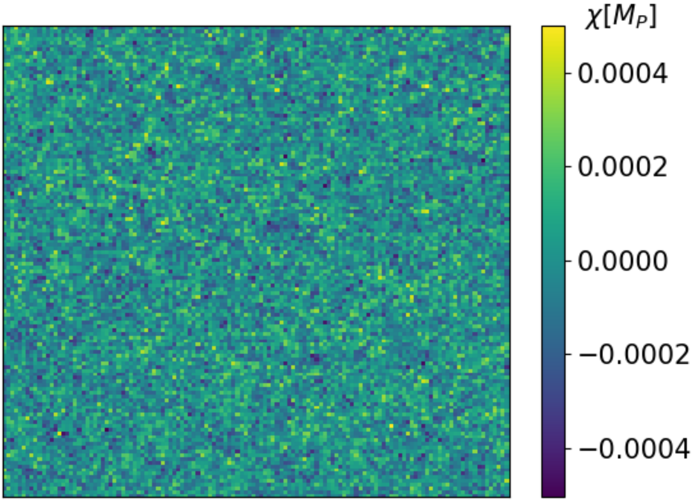


- Initially the lower frequency modes are strongly destabilized. After that the higher energy modes growths and finally destabilization fades out.

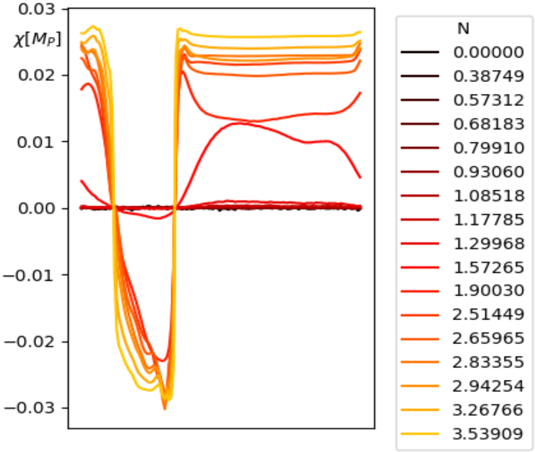
Density plot for χ evolution for $M_{\rm np} = 10^{-1.5} M_P$



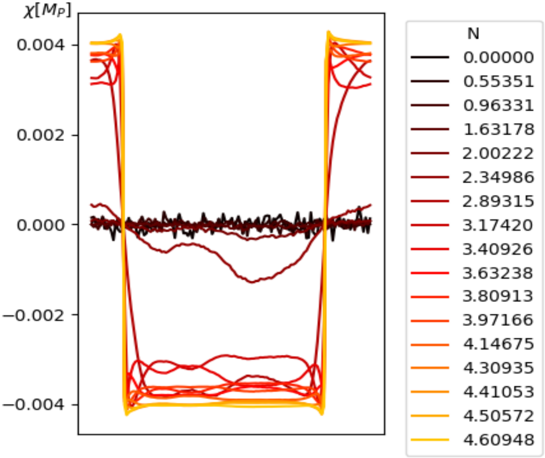
Density plot for χ evolution for $M_{\rm np} = 10^{-2} M_P$



Plot of χ evolution on chosen line intersection of the lattice for $M_{\mathrm{np}} = 10^{-1.5} M_P$

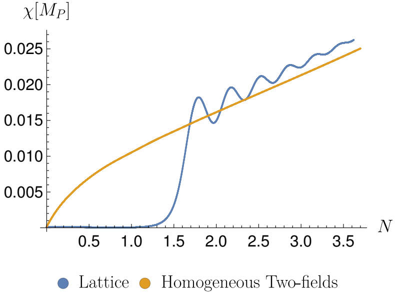


Plot of χ evolution on chosen line intersection of the lattice for $M_{\text{np}} = 10^{-2} M_P$

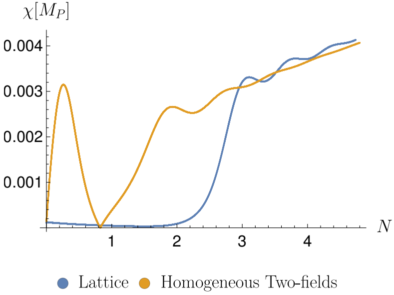


Comparison of χ evolution obtained from lattice simulation and from homogeneous two-fields simulation

$M_{\mathrm{np}} = 10^{-1.5} M_P$

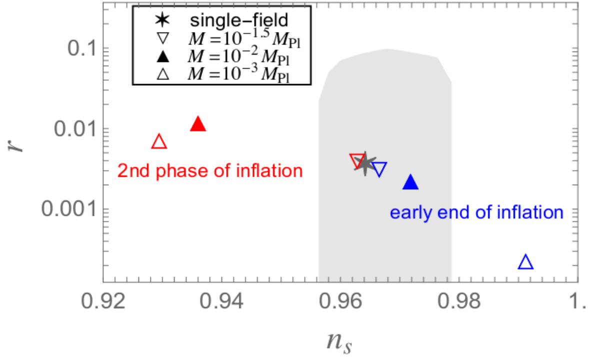


$M_{\mathrm{np}} = 10^{-2} M_P$



- the trajectory obtained in lattice simulations is very similar to the one obtained in the two-fields homogeneous simulation with the initial value of field χ set to $H_c/2\pi$

The shift of the models predictions due to geometrical destabilization



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- The Geometrical destabilization of inflation causes the prolonged period of inflation, which decreases the value of predicted spectral index

Summary of the analysis of geometrical destabilization of inflation

- Lattice simulations have shown, that geometrical destabilization strongly affects inflationary trajectory.
- Homogeneous domains with the same absolute value of field χ, but the opposite signs are created.
- Inside such domains the second prolonged period of inflation takes place, which shifts the CMB predictions of the model.

Thank you for your attention!