Subcritical Hybrid Inflation in Generalized Superconformal Model

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Based on arXiv: 2104.02248

with Koji Ishiwata (Kanazawa University)

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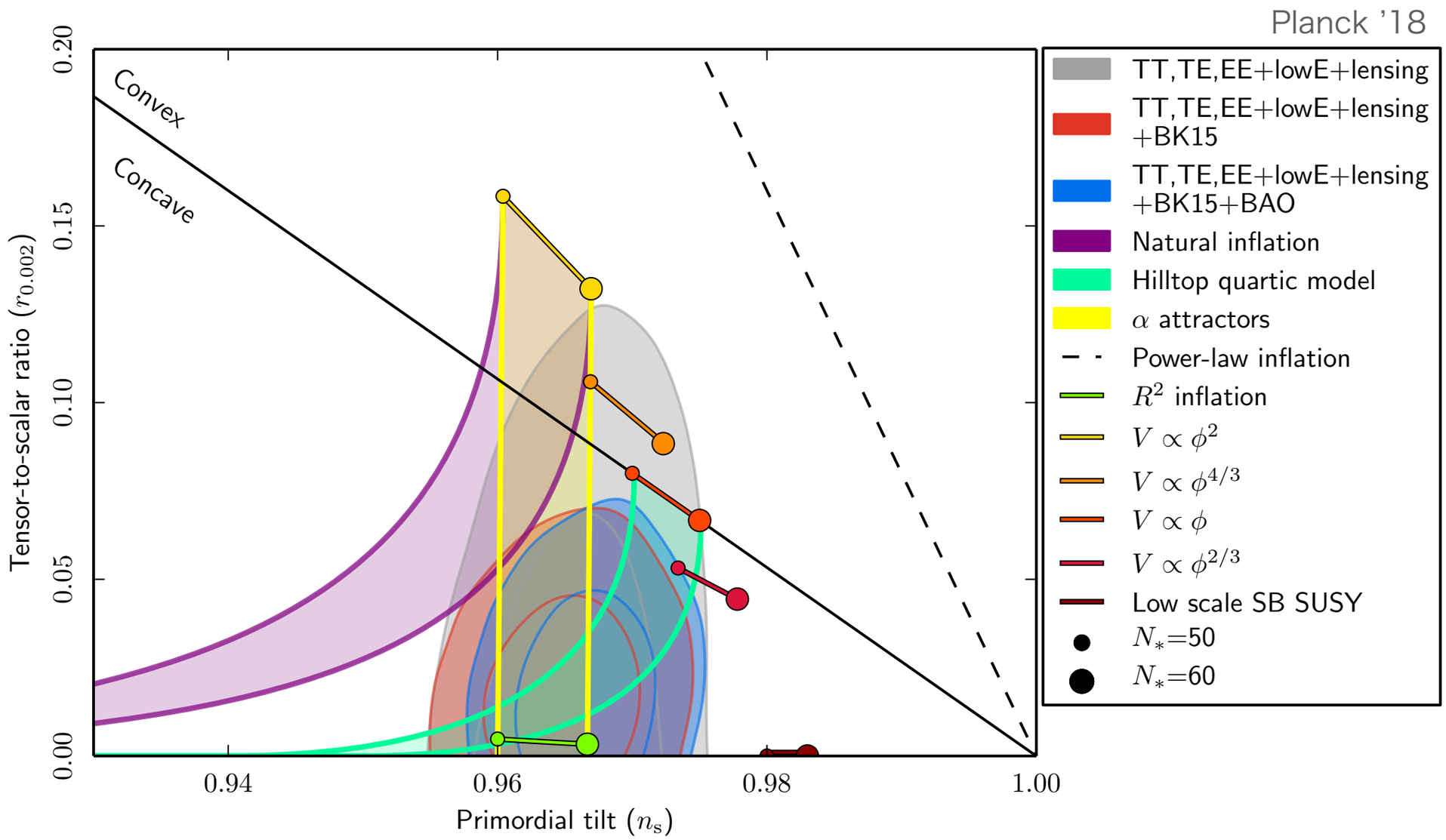
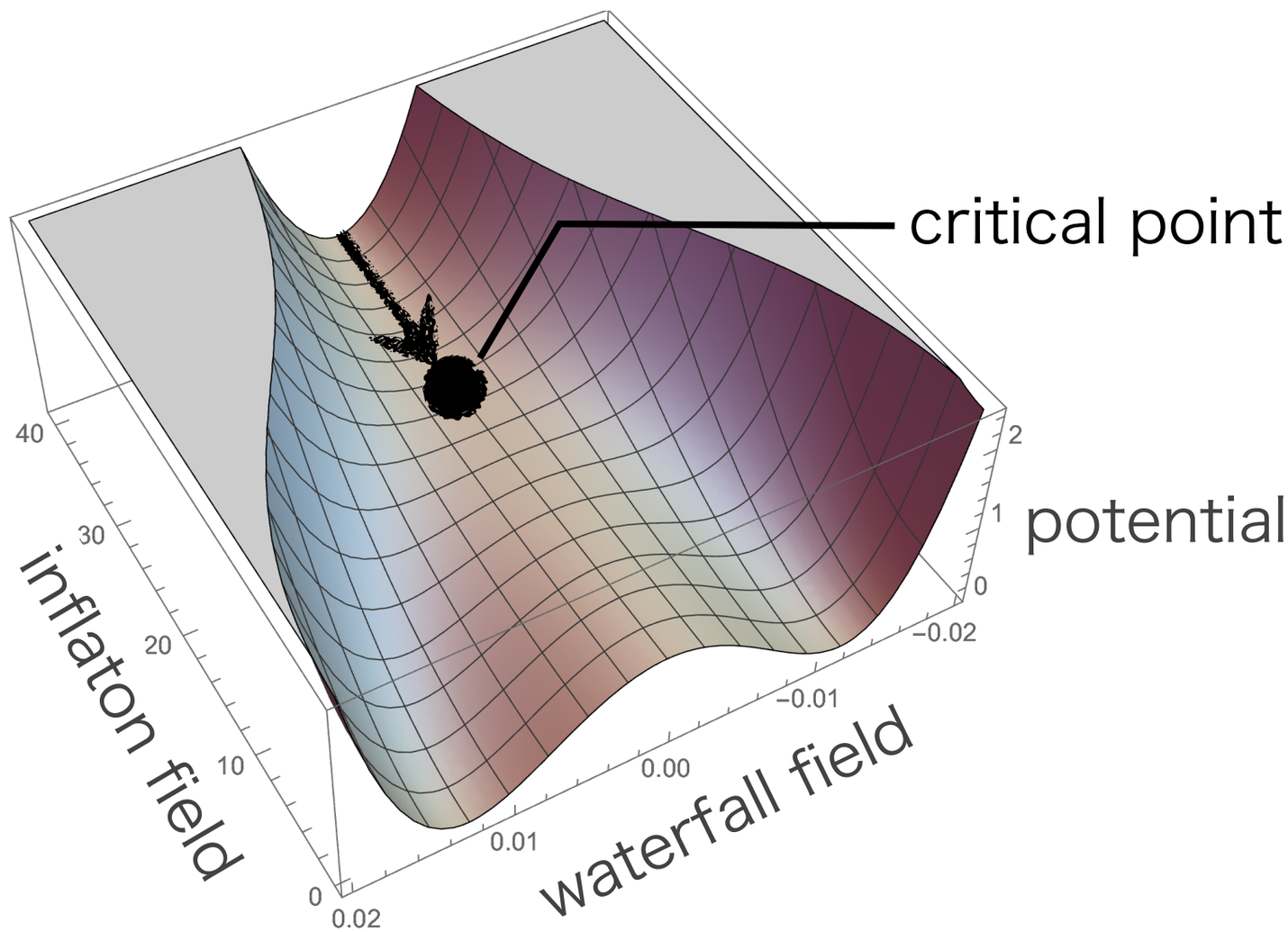
Inflation



Many inflation models have been proposed so far

Hybrid inflation Linde '93

- Inflation occurs until slow-rolling inflaton reaches the critical point
- It is simple model but not consistent with current CMB observations



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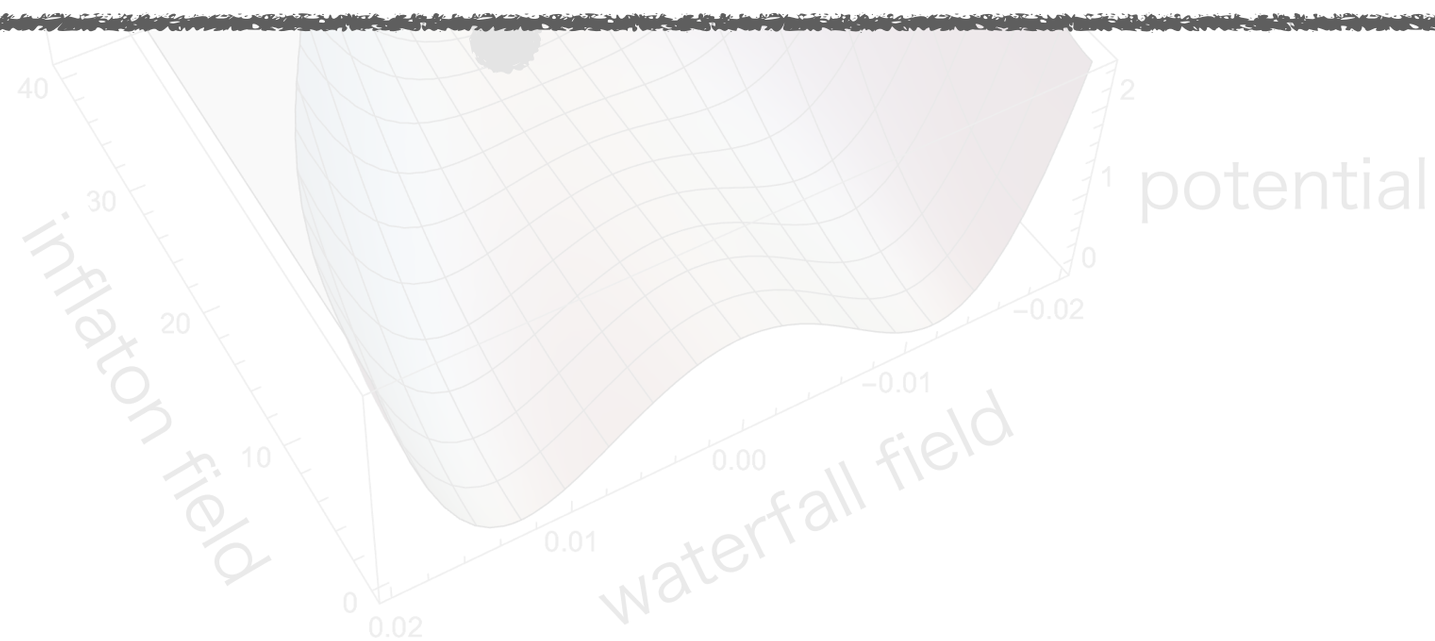
D-term hybrid inflation is revisited from new point of view



Various types of D-term hybrid inflation are realized depending on the symmetry of the Kähler potential

- Superconformal symmetry — Starobinsky type
  Buchmuller, Domcke, Schmitz '13
  Buchmuller, Domcke, Kamada '13

- Shift symmetry — Chaotic regime (after critical point)
  Buchmuller, Domcke, Schmitz '14
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- Superconformal
  + approx. shift symmetry — α-attractor type (after critical point)
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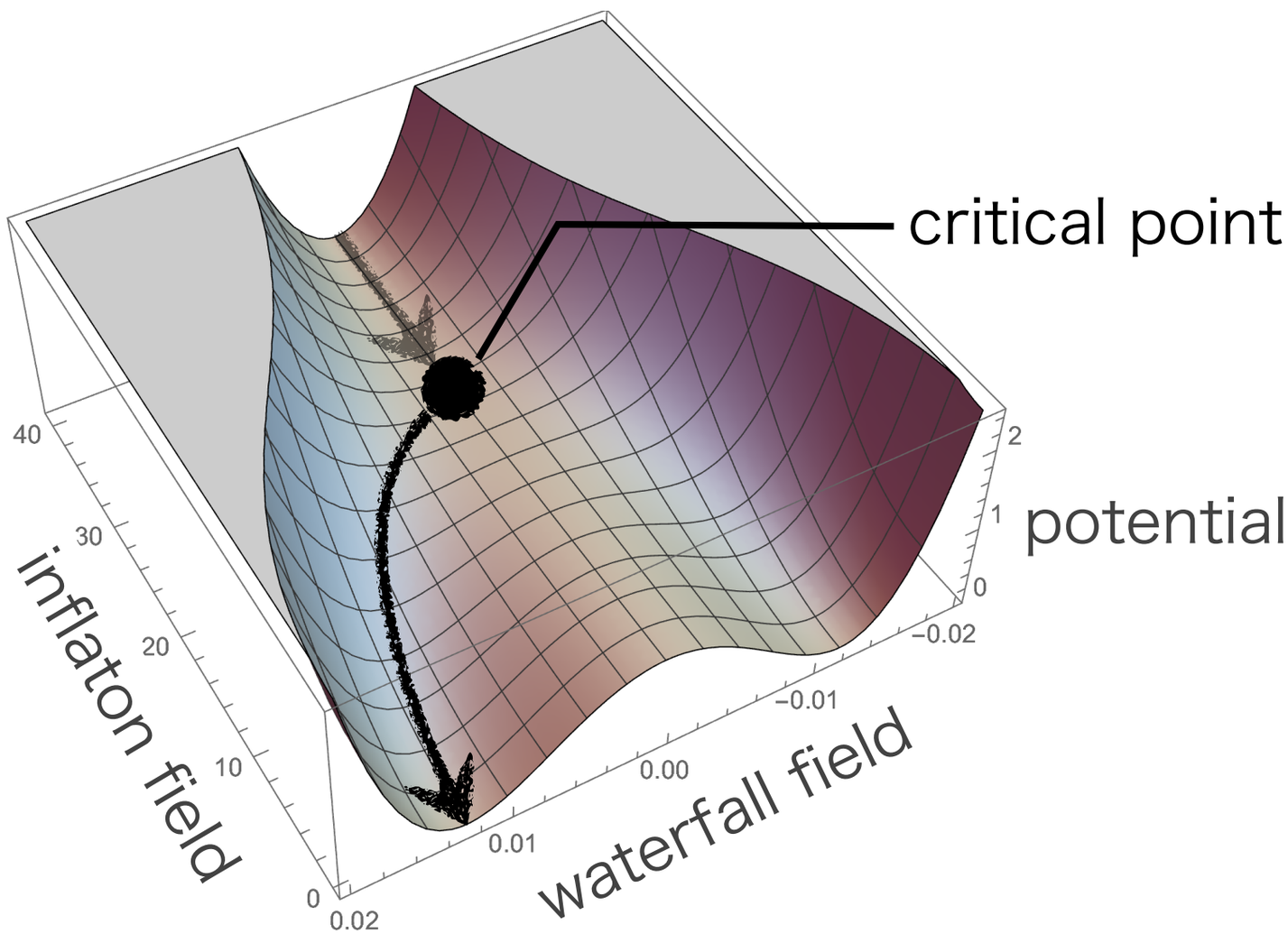
Subcritical hybrid inflation

- Inflaton keeps slow-rolling after crossing the critical point
- Inflation continues in subcritical regime with growth of waterfall field



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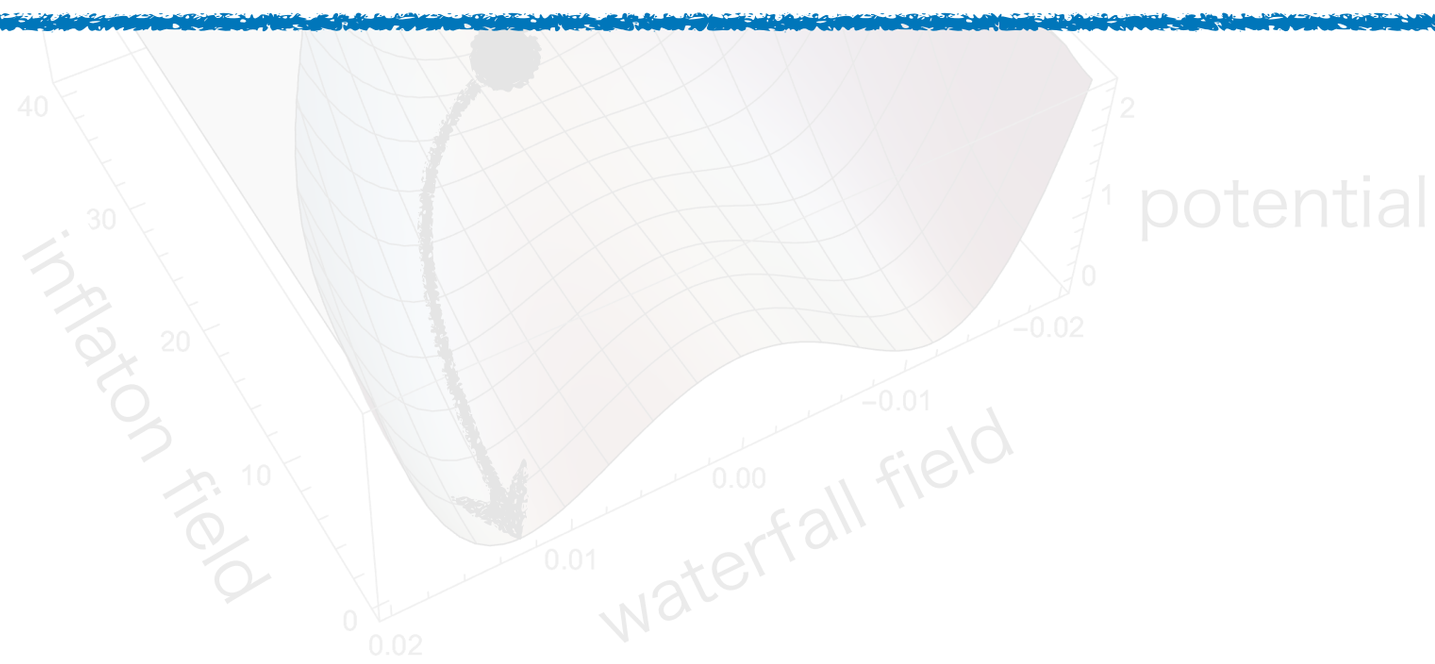
We study subcritical hybrid inflation
in a generalized version of superconformal model



Model

Model

- Superpotential

$$W = \lambda S_+ S_- N$$

	S_+	S_-	N
U(1)	q	$-q$	0

$q > 0$

- Kähler potential

$$K = -3\alpha \log\left(-\frac{\Phi}{3}\right)$$

$\alpha = 1$ in typical model

$\alpha > 0$ in our model

$$\Phi = -3 + |S_+|^2 + |S_-|^2 + |N|^2 + \underbrace{\frac{\chi}{2}(N^2 + \bar{N}^2)}_{\text{superconf. breaking term}}$$

$\phi \equiv \sqrt{2}\,\mathrm{Re}\,N$: inflation field

$s \equiv \sqrt{2}\,|S_+|$: waterfall field

$M_{\mathrm{pl}} = 1$

Model

- F-term

$$V_F = \left(-\frac{\Phi(\phi, s)}{3}\right)^{1-3\alpha} \frac{\lambda^2}{4\alpha}\phi^2 s^2$$

- D-term

$$V_D = \frac{g^2}{8}\left[\left(-\frac{\Phi(\phi, s)}{3}\right)^{-1} \alpha q s^2 - 2\xi\right]^2$$

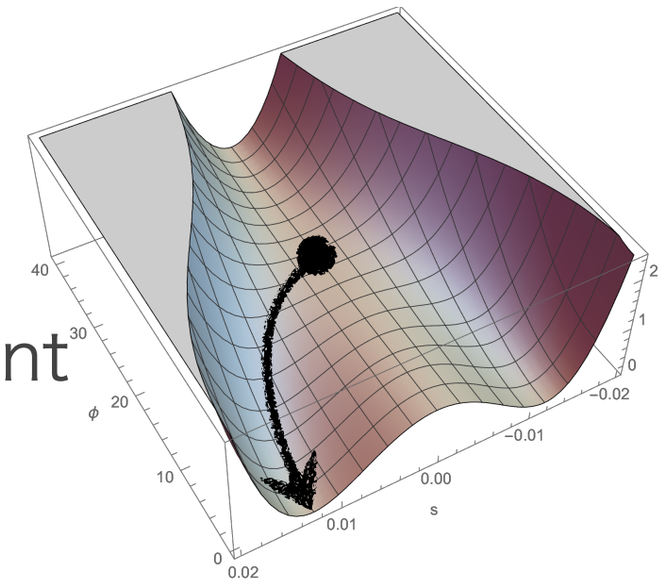
$$\Phi(\phi, s) = -3 + \frac{1}{2}\left(s^2 + (1+\chi)\phi^2\right)$$

g : gauge coupling constant

ξ : constant Fayet-Iliopoulos term $(\xi > 0)$

Model

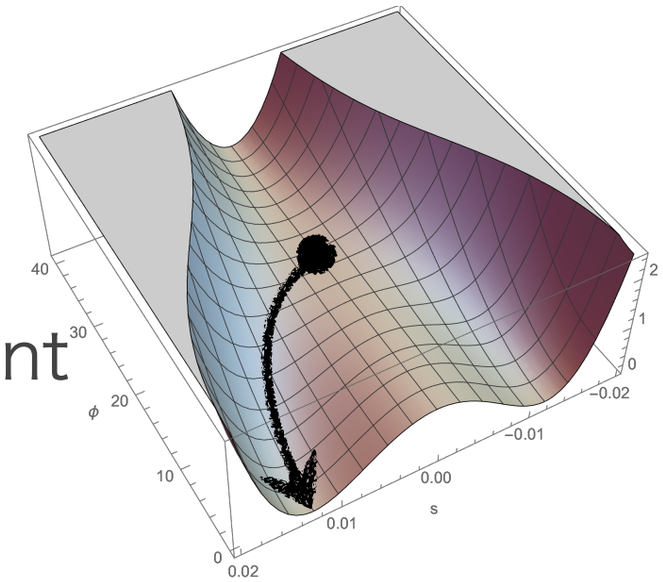
$s = s_{\min}(\phi)$ after critical point



Model

$$V_{\text{tot}}(\phi, s) = V_F + V_D$$

$s = s_{\text{min}}(\phi)$ after critical point



Potential in subcritical regime

$$V(\phi) = g^2\xi^2\,\Psi(\phi)\left(1 - \frac{1}{2}\Psi(\phi)\right)$$

$$\Psi(\phi) = \frac{k}{2\alpha^2}\left(\frac{\Phi(\phi,0)}{3}\right)^{2-3\alpha}\phi^2$$

$$k \equiv \lambda^2/qg^2\xi$$

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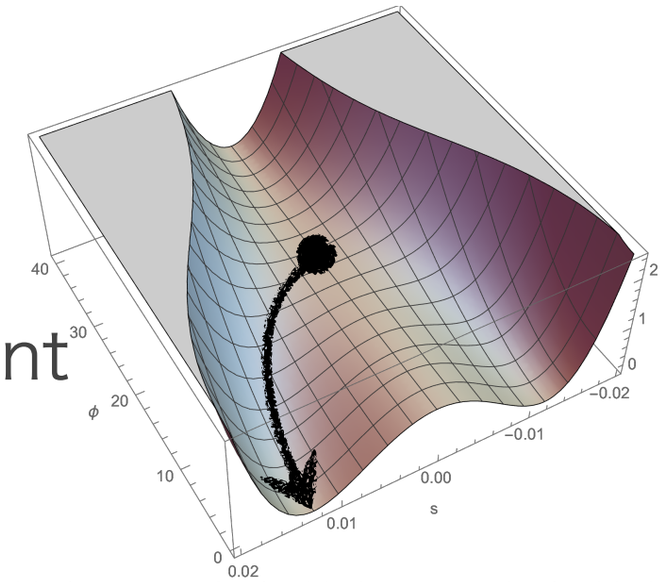

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Use $V(\phi)$ to identify params. consistent with CMB

& to clarify prediction of tensor-to-scalar ratio r

Results

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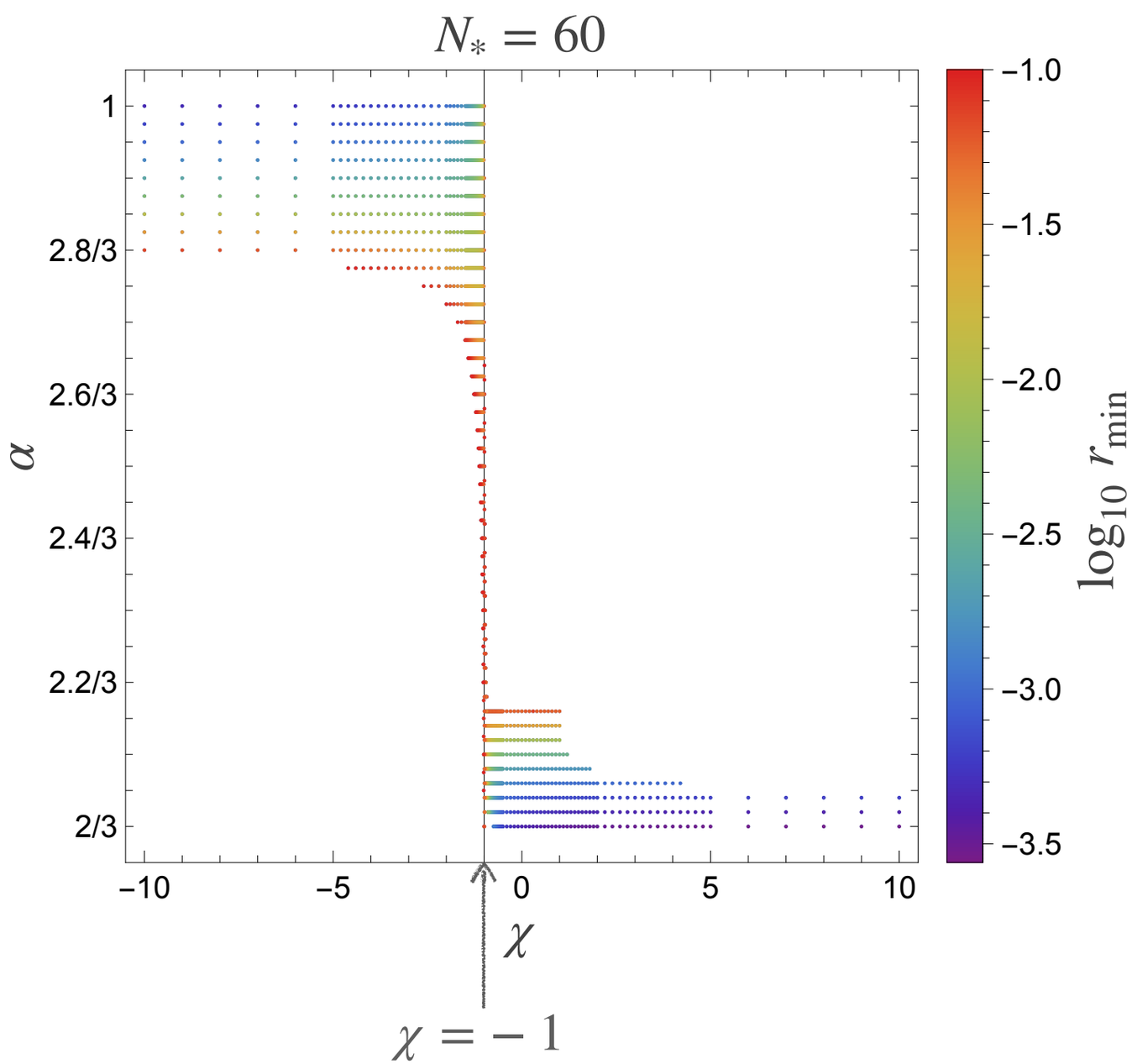
Allowed region for α & χ for 60 e-folds



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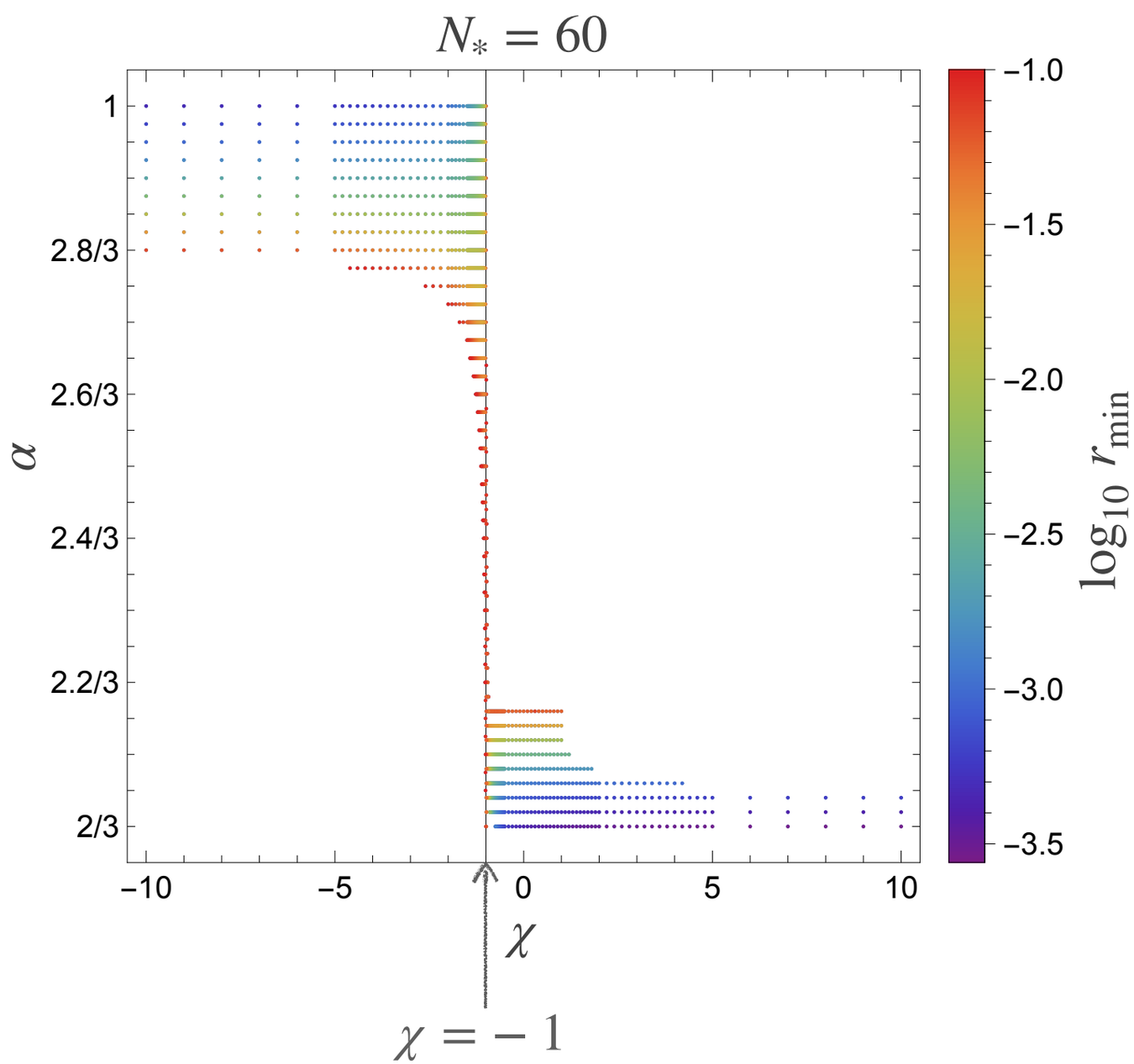


- Behavior of allowed region changes around $\chi = -1$:

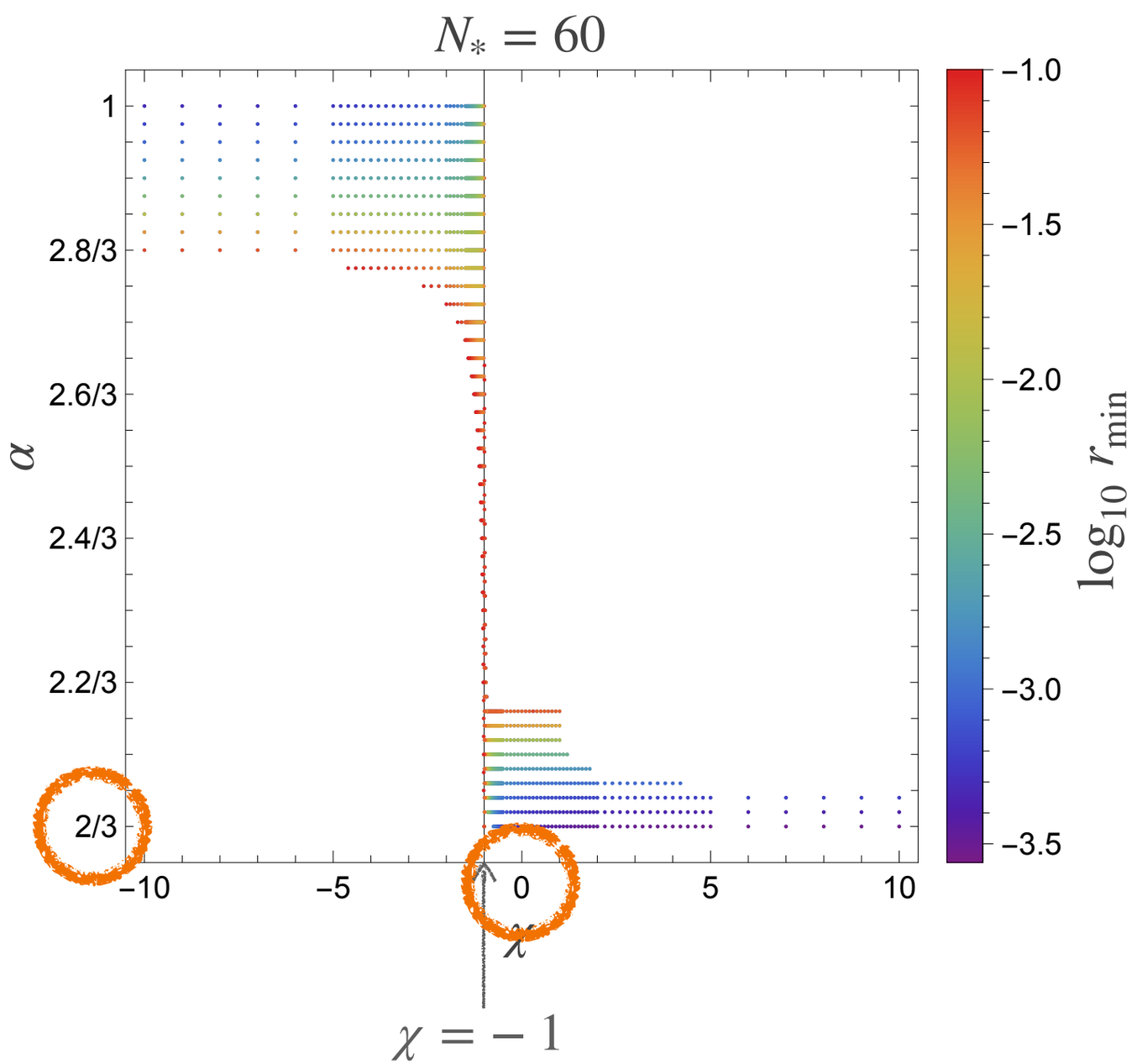
$$\begin{cases} \alpha \simeq 1 & (\chi \lesssim -5) \\ 2/3 \lesssim \alpha \lesssim 1 & (\chi \simeq -1) \\ \alpha \simeq 2/3 & (\chi \gtrsim 5) \end{cases}$$

- Predicted r changes depending on α & χ :

$10^{-4} \lesssim r \lesssim 10^{-1}$

Results

Allowed region for α & χ for 60 e-folds



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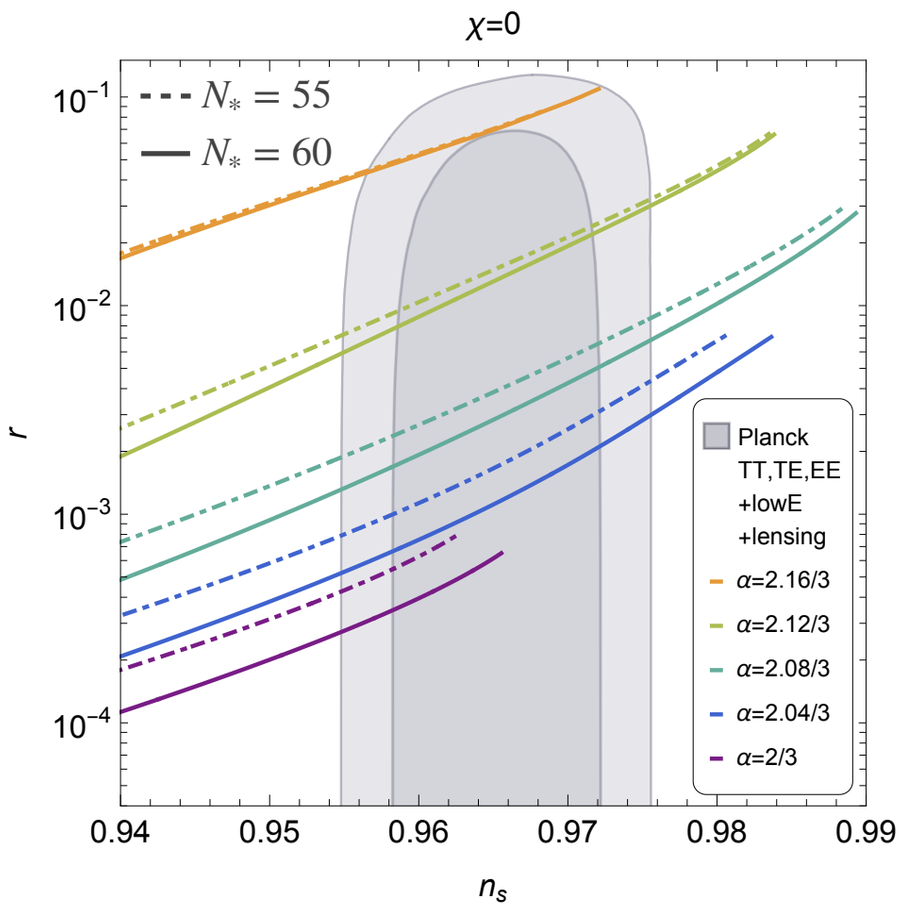
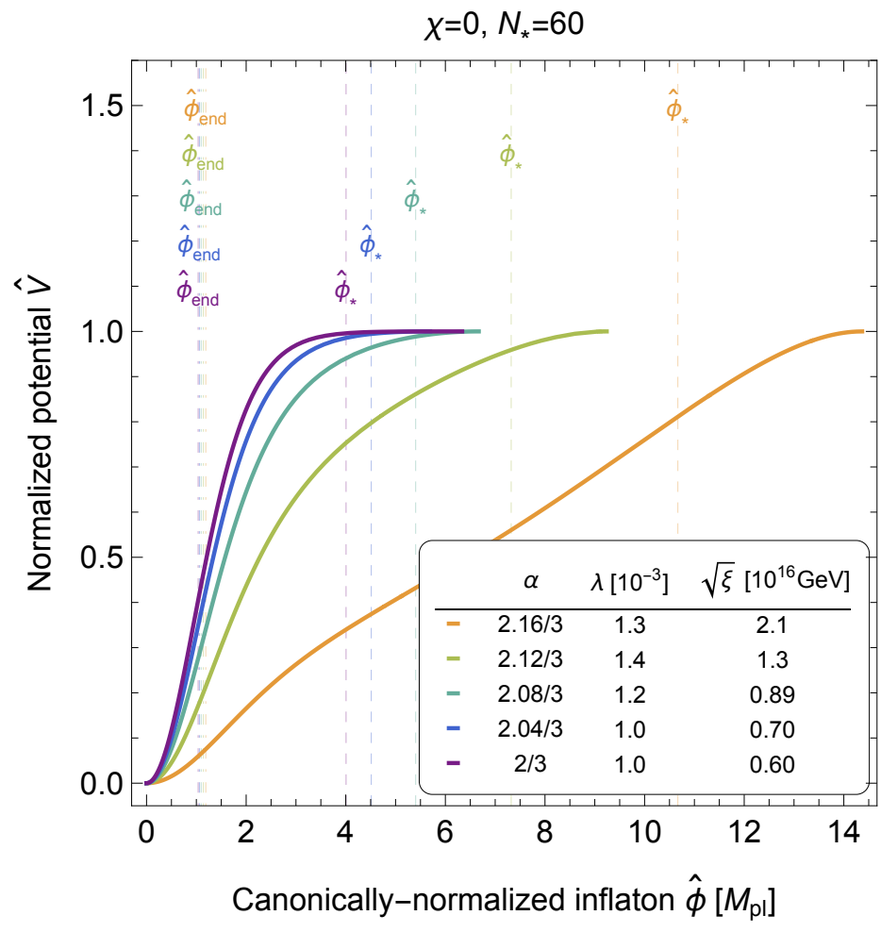
Results $\chi = 0$





As $\alpha \to 2/3$:

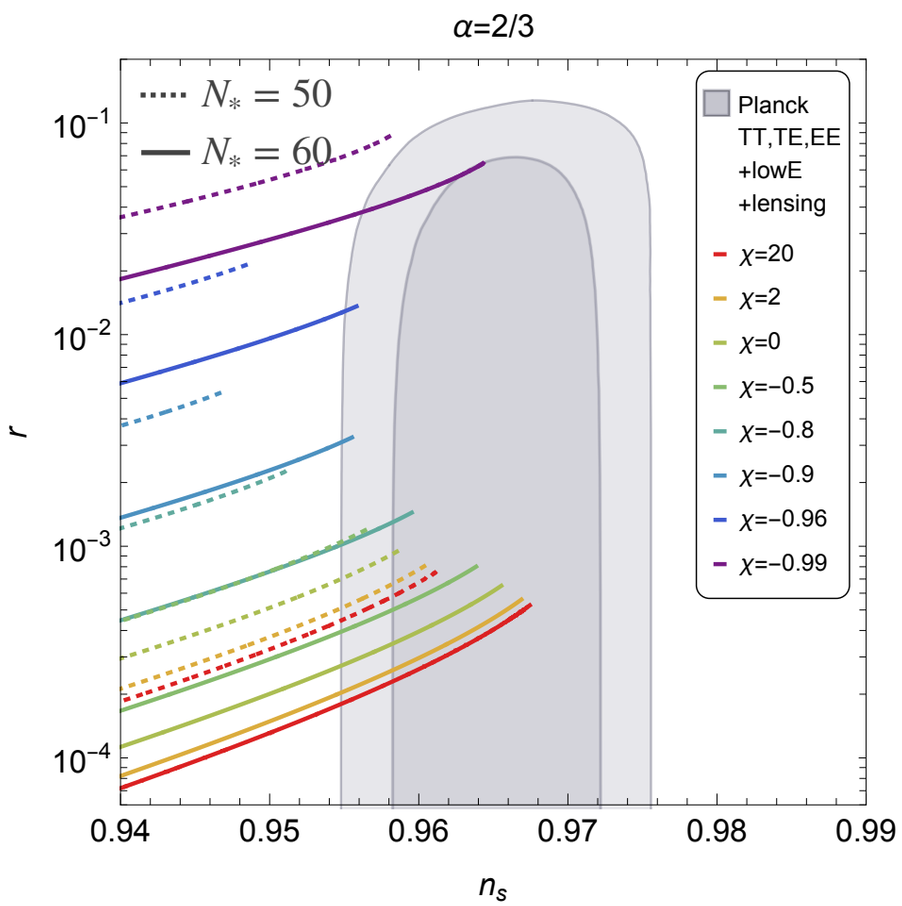
- $\hat{V}$ becomes flatter
- $\hat{\phi}_*$ becomes smaller
- r becomes smaller

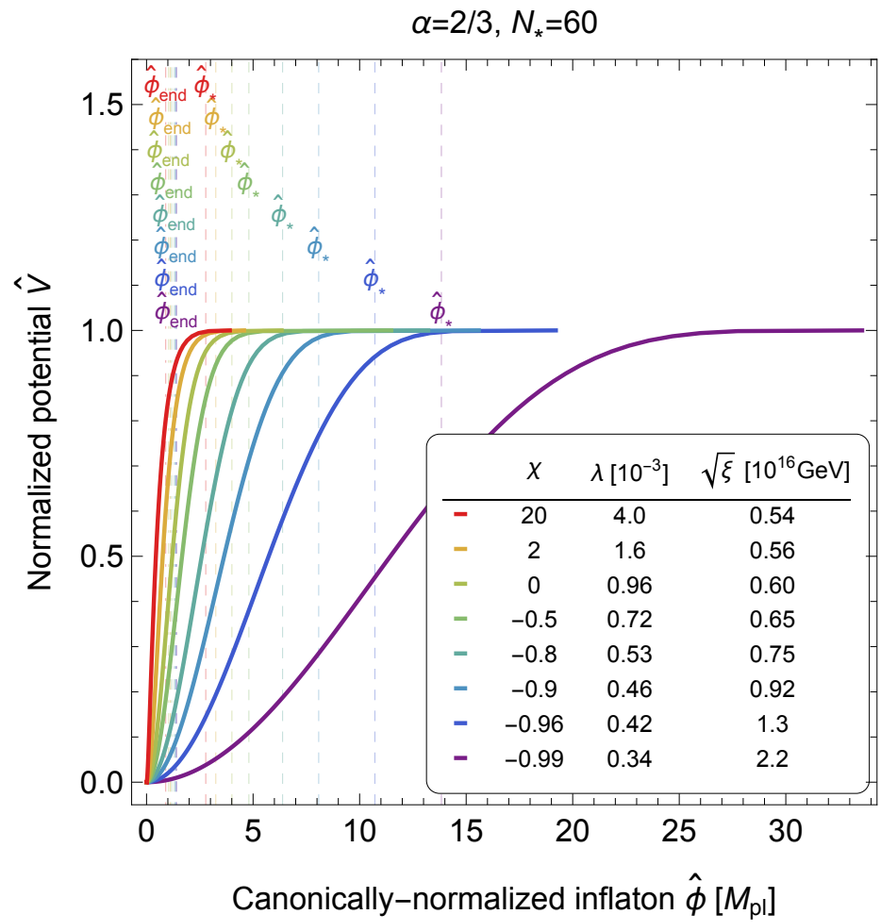
$\hat{V} = V/V(\phi_c)$

$\hat{\phi} = \hat{\phi}_{\rm end}$ at the end of inflation

$\hat{\phi} = \hat{\phi}_*$ at $60\,e$-folds

Results $\alpha = 2/3$





As χ increases :

- $\hat{V}$ becomes flatter
- $\hat{\phi}_*$ becomes smaller
- r becomes smaller

$\hat{V} = V/V(\phi_c)$

$\hat{\phi} = \hat{\phi}_{\rm end}$ at the end of inflation

$\hat{\phi} = \hat{\phi}_*$ at $60\,e$-folds

Summary

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We have studied subcritical regime of D-term hybrid inflation in a generalized superconformal model

- Successful inflation is realized in wide range of parameters
- Potential changes drastically depending on α & χ
- r is fond to range from 10^{-4} to 10^{-1}