Minimal gauge inflation

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Based on

- J.-O. Gong and S. C. Park, arXiv:0801.0333 [hep-ph]

Outline

1. Introduction
2. The model
3. Cosmological evolution
4. Conclusions

Inflation and the inflaton field

Inflation$\cdots$

1. can resolve many cosmological problems e.g. horizon problem
2. provides the desired initial conditions of the hot big bang evolution
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We need a ***FLAT INFLATON POTENTIAL***

Question: how to force the inflaton to have flat enough potential *naturally*?
Answer: we may resort to the *symmetry*

Identifying the inflaton

Inflaton = 5D non-Abelian gauge field in hidden sector

⇒ natural inflation

$$V \sim \Lambda^4 \left[1 \pm \cos\left(\frac{\phi}{f}\right) \right]$$

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4. less constrained

$SU(2)$ gauge theory on the orbifold

Gauge theory on $S^1/\mathbb{Z}_2$: Two independent parity conditions at $y = 0, \pi R$ as

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\begin{aligned}
A_\mu(x,-y) &= P_0 A_\mu(x,y) P_0 \\
A_5(x,-y) &= -P_0 A_5(x,y) P_0 \\
A_\mu(x,\pi R - y) &= P_1 A_\mu(x,\pi R + y) P_1 \\
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Taking $P_0 = P_1 = \mathrm{diag}(1,-1)$, parity assignment with P_0 and P_1

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Zero modes: mirror photon A_μ^3 and inflaton $A_5^{1,2} \to \phi$

1-loop inflaton potential

Induced one-loop effective potential of ϕ

$$V_{1-\text{loop}}(\phi) = -\frac{9}{(2\pi)^6 R^4} \sum_{n=1}^{\infty} \frac{\cos(n\phi/f_{\text{eff}})}{n^5}$$

with the effective decay constant

$$f_{\text{eff}} = (2\pi g_{4\text{D}} R)^{-1}$$

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The radiatively generated inflaton potential

$$V(\phi) = \frac{9}{(2\pi)^6 R^4} \sum_{n=1}^{\infty} \frac{1}{n^5} \left[1 - \cos\left(\frac{n\phi}{f_{\text{eff}}} \right) \right]$$

with a cosmological constant $9\zeta(5) R^{-4}/(2\pi)^6$

Observable quantities

Leading approximation: $n = 1$ piece → NATURAL INFLATION

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Observable quantities first order in the slow-roll approximation

$$\mathscr{P}_{\mathscr{R}}^{1/2} = \sqrt{\frac{8V}{3\epsilon M_{\rm Pl}^4}}$$

$$n_{\mathscr{R}} = 1 - 6\epsilon + 2\eta$$

$$r = 16\epsilon$$

$$-\frac{3}{5}f_{\rm NL} = \frac{1}{2}\left[\left(3 + f_k\right)\epsilon - \eta\right]$$

with

$$\epsilon \equiv \frac{M_{\rm Pl}^2}{16\pi^2}\left(\frac{V'}{V}\right)^2 \qquad \eta \equiv \frac{M_{\rm Pl}^2}{8\pi}\frac{V''}{V}$$

Analytic estimates with $n = 1$ piece

$$
\mathcal{P}_{\mathcal{R}}^{1/2} = \frac{8\sqrt{3}}{(2\pi)^{5/2}} \frac{f_{\rm eff}/M_{\rm Pl}}{(RM_{\rm Pl})^2} \left\{ 2 - \frac{32\pi (f_{\rm eff}/M_{\rm Pl})^2}{16\pi (f_{\rm eff}/M_{\rm Pl})^2 + 1} \exp\left[\frac{-N}{8\pi (f_{\rm eff}/M_{\rm Pl})^2} \right] \right\}
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$$

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Analytic estimates vs numerical results

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$\log_{10}(f_{\rm eff}/M_{\rm Pl}) = 0.00$	analytic	4.96×10^{-5}	0.952	0.032
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→ Taking $n = 1$ piece is reasonably good

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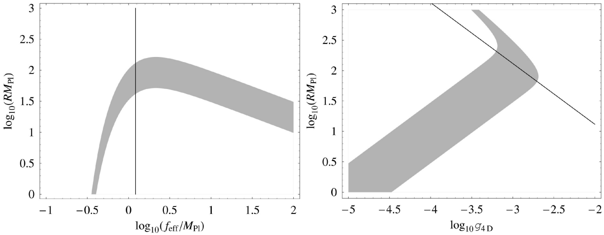

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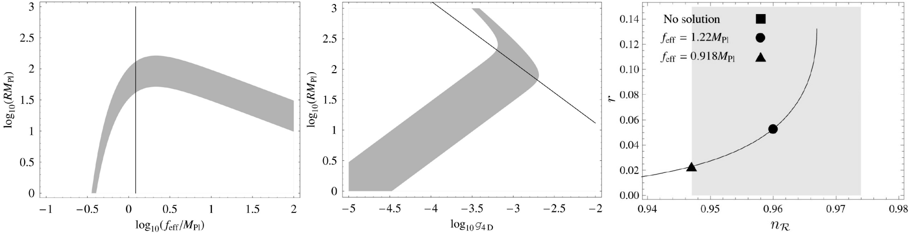

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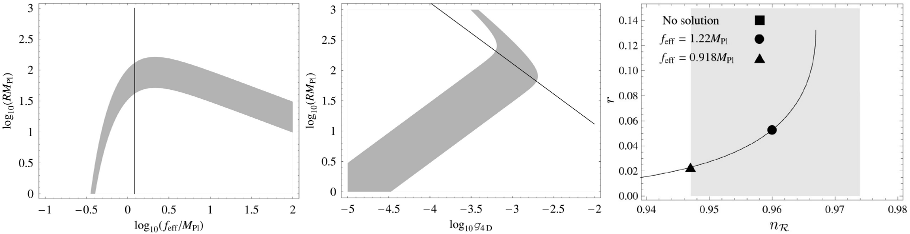

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- As $f_{\rm eff}/M_{\rm Pl} \to \infty$, with N being the number of e-folds, $n_{\mathcal{R}}$ and r are saturated
- Good agreement when the model parameters are$\cdots$

$$\begin{cases} \text{perturbative gauge interaction} & (g_{4D} \lesssim (2\pi RM_{\rm Pl})^{-1}) \\ \text{moderately compactified radius} & (10 \lesssim RM_{\rm Pl} \lesssim 100) \end{cases}$$

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$$T_{\text{RH}} \lesssim \mathcal{O}(0.1)\sqrt{\Gamma_{\text{grav}} M_{\text{Pl}}} \sim \mathcal{O}(0.1) \frac{M_{\text{Pl}}}{(f_{\text{eff}}/M_{\text{Pl}})^{3/2} (RM_{\text{Pl}})^3}$$

e.g. $f_{\text{eff}}/M_{\text{Pl}} = 1$ and $RM_{\text{Pl}} = 100 \rightarrow T_{\text{RH}}^{\text{max}} \sim 10^{12-13}\text{GeV}$

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2. In a wide range of model parameters...

$$1 \lesssim f_{\rm eff}/M_{\rm Pl} \lesssim 100 \, , \quad 10 \lesssim R M_{\rm Pl} \lesssim 100$$

$$\mathcal{P}_{\mathcal{R}}^{1/2} \sim 10^{-5} \, , \quad n_{\mathcal{R}} \sim 0.96 \, , \quad r \sim 0.05$$

consistent with the most recent observations