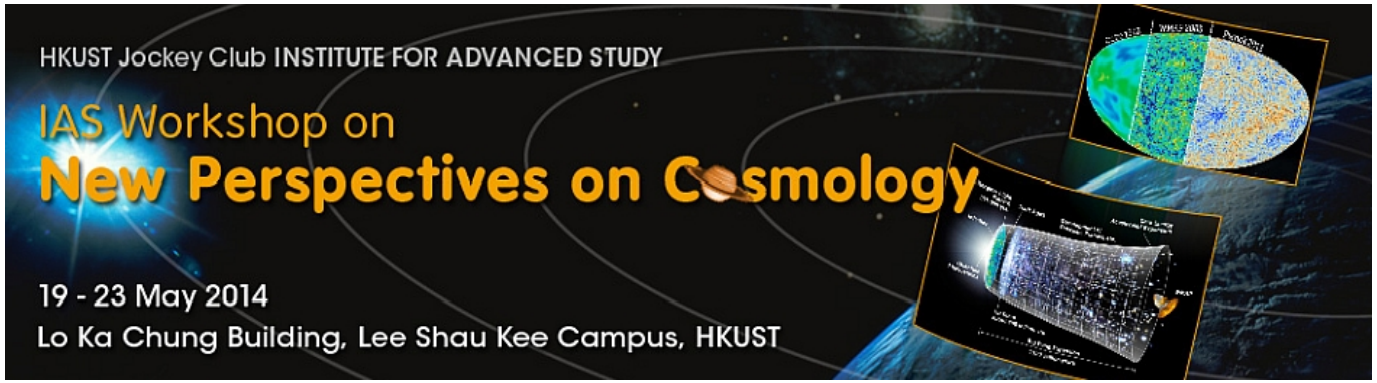

Helical Inflation and Cosmic Strings

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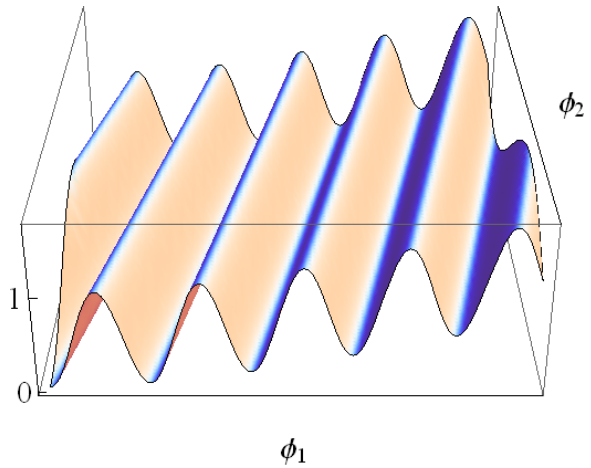
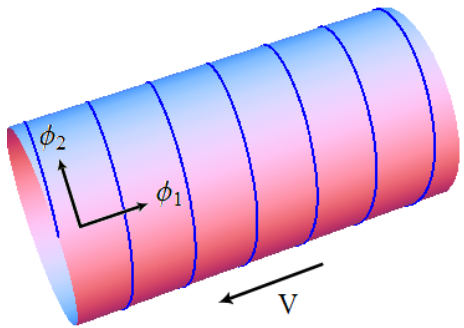
May 20, 2014

Outline

POTENTIAL

$$V(\phi_1, \phi_2) = V_0 \left\{ 1 - \cos\left(\frac{\phi_1}{f_1}\right) + A\left[1 - \cos\left(\frac{\phi_1}{f_1'} - \frac{\phi_2}{f_2}\right)\right]\right\}$$





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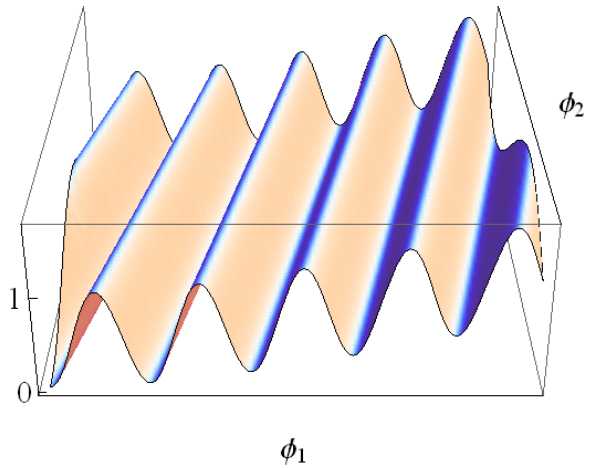

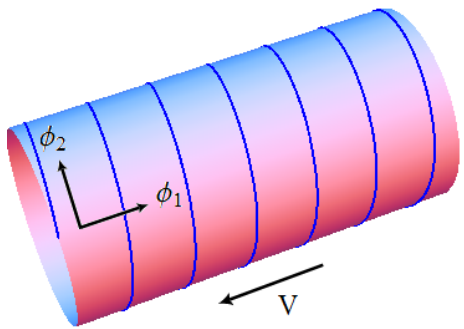

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MOTIVATION

$$V_{eff}(\phi) \simeq V_0 \left[1 - \cos\left(\frac{\phi}{f_{eff}}\right)\right], \qquad f_{eff} \simeq \frac{f_1 f_2}{f_1'}$$

- Large field inflation
- Sub-Planckian $f_i \rightarrow$ super-Planckian f_{eff}

  J. E. Kim, H. P. Nilles and M. Peloso, JCAP **0501** (2005) 005 [hep-ph/0409138]
- Free from UV corrections due to axion symmetry $\phi \rightarrow \phi + 2\pi f$
- Realization in SUGRA

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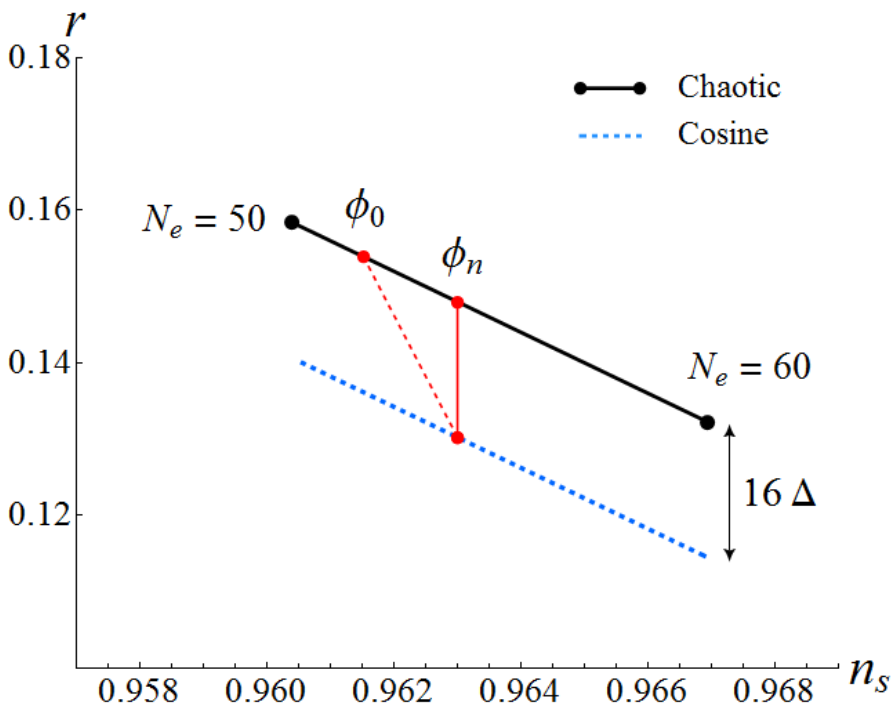
$N_e = 60 - 50$	n_s	r	$\hat{\Delta} = r + 4(n_s - 1)$
Chaotic Inflation	$0.967 - 0.960$	$0.132 - 0.158$	0
Helical Model ($\frac{f_1 f_2}{f_1'} = 20 M_{pl}$)	$0.966 - 0.960$	$0.124 - 0.150$	-0.011
Helical Model ($\frac{f_1 f_2}{f_1'} = 14 M_{pl}$)	$0.966 - 0.960$	$0.115 - 0.141$	-0.020
Experimental Data	0.9607 ± 0.0063	$0.16^{+0.06}_{-0.05}$	

COSINE FEATURE

$$\hat{\Delta} = 16\Delta = r + 4(n_s - 1)$$

$$\Delta_{\phi^2} = 0, \qquad \Delta_{cosine} = -\frac{1}{4f^2}$$



COSINE FEATURE

$V(\phi)$	$\frac{1}{2}m^2\phi^2$	$V_0\left[1-\cos\left(\frac{\phi}{f}\right)\right]$
$\epsilon = \frac{1}{2}\left(\frac{V'}{V}\right)^2$	$\frac{1}{16}r$	$\frac{1}{16}r$
$\eta = \left(\frac{V''}{V}\right)^2$	$\frac{1}{16}r$	$\frac{1}{16}r + 2\Delta$
$\xi^2 = \frac{V'V'''}{V^2}$	0	$\frac{1}{2}r\Delta$
$\omega^3 = \frac{V'^2V''''}{V^3}$	0	$\frac{1}{32}r^2\Delta + r\Delta^2$
$n_s - 1 = 2\eta - 6\epsilon$	$-\frac{1}{4}r$	$-\frac{1}{4}r + 4\Delta$
$n_t = -2\epsilon$	$-\frac{1}{8}r$	$-\frac{1}{8}r$
$\frac{dn_s}{d\ln k} = -16\epsilon\eta + 24\epsilon^2 + 2\xi^2$	$\frac{1}{32}r^2$	$\frac{1}{32}r^2 - r\Delta$
$\frac{dn_t}{d\ln k} = -4\epsilon\eta + 8\epsilon^2$	$\frac{1}{64}r^2$	$\frac{1}{64}r^2 - \frac{1}{2}r\Delta$
$\frac{d^2n_s}{d\ln k^2} = -192\epsilon^3 + 192\epsilon^2\eta - 32\epsilon\eta^2$ $-24\epsilon\xi^2 + 2\eta\xi^2 + 2\omega^3$	$-\frac{1}{128}r^3$	$-\frac{1}{128}r^3 + \frac{3}{8}r^2\Delta - 4r\Delta^2$

COSINE FEATURE

Independent ways of measuring Δ,

$$8\Delta^2 = \frac{1}{2}(n_s - 1)^2 - \frac{dn_s}{d\ln k}, \qquad \hat{\Delta} = 16\Delta = \frac{r}{2} - \frac{32}{r}\frac{dn_t}{d\ln k}$$

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Bounds on $\hat{\Delta}$,

$$m^2 = \frac{V_0}{f^2} \simeq 4 \times 10^{-11} M_{pl}^2$$

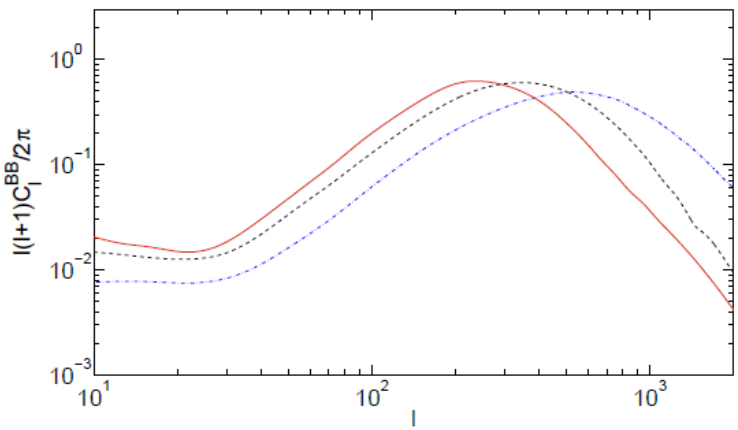
$$\hat{\Delta} = -\frac{4M_{pl}^2}{f^2} = -0.03\frac{V_{infl}}{V_0} = -0.03\frac{(2\times 10^{16} GeV)^4}{V_0}$$

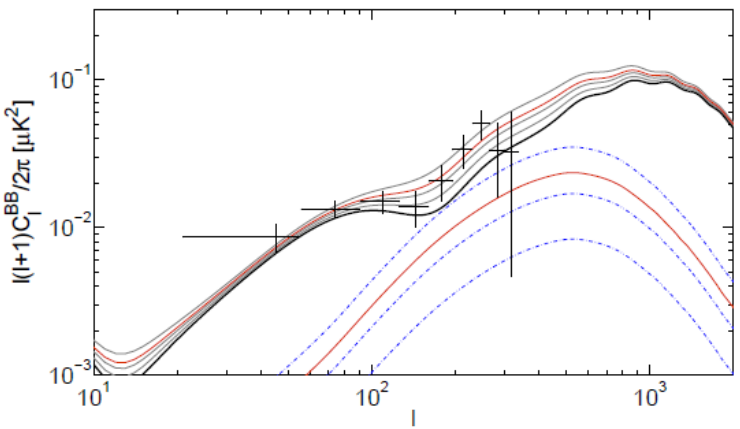
$$M_{pl} \gg M_S \geq M_{GUT} \simeq 2 \times 10^{16} GeV$$

COSMIC STRINGS

- $V_{infl} \simeq M_{GUT}$
- Many axions and $U(1)$ gauge fields $\rightarrow$ vortices
- Evolving to scaling network, properties reliably calculated

COSMIC STRINGS





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CONCLUSION

- Natural inflation looks natural
- Looking foward to see more experimental results
- Cosmic strings
- GUT again?