

Congratulations BICEP!

Congratulations Andrei et al!

$r = \frac{\text{Tensor}}{\text{Scalar}}$ is related to field range
in simple inflation

$$\frac{\Delta\phi}{M_p} \sim \frac{r^{\frac{1}{2}} N_e}{\sqrt{8}} \gg 1 !$$

highly UV sensitive
if ≥ 1

BICEP2

↳ An ∞ sequence of possible terms

$$V \rightarrow V \left(1 + \sum_n c_n \frac{(\phi - \phi_0)^n}{M_p^n} \right) \quad \text{infinitely "UV-sensitive"}$$

must be suppressed (e.g. symmetry)

→ Determined by Quantum Gravity theory

→ B-modes test string-theoretic large-field inflation in particular.

Lyth ~~"Bound"~~

$$N_e = \int \frac{da}{a} = \int \frac{da}{dt} dt = \int H dt$$

$$= \int \frac{H M_p}{\dot{\phi}} \frac{d\phi}{M_p} = \sqrt{8} r^{-\frac{1}{2}} \frac{\Delta\phi}{M_p}$$

Using

$$r = \frac{\gamma\gamma}{\beta\beta} = \frac{\text{tensor}}{\text{Scalar}} \sim \frac{\frac{H^2}{M_p^2}}{\frac{H^4}{\dot{\phi}^2}}$$

Large-field inflation arises
 via a robust mechanism in
 string theory

Axions / Nflation / Monodromy

Dimopoulos
 Kachru
 McGreevy
 Wacker
 Easther
 McA.
 Liddle...

answering the
 basic yes/no
 question

'08 ES, Westphal, McAllister
 D'Amico Kaloper Sorbo
 Gobbetti Lawrence Dong
 Kleban Flauger Horn
 Schillo Pajer Roberts
 ...

cf chaotic I., Natural I.

These fields descend from higher-
 dimensional Electro-magnetic potentials

$$a = \int_{\text{circle}} A_\mu dx^\mu$$

$$\mathcal{L} = F_{MN}^2 - (A_M + \partial_M \theta)^2 + \dots$$

$D > 4$

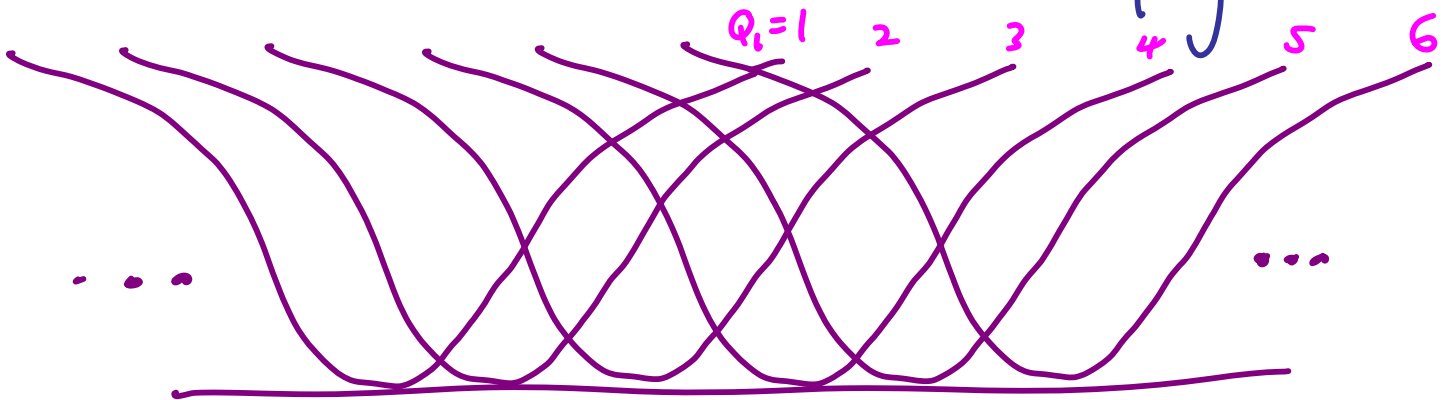
Gauge-Invariant

$$A_M \rightarrow A_M + \partial_M \Lambda$$

$$\theta \rightarrow \theta - \Lambda$$

→ 4d $V(\phi_a) \sim \mu^{4-p} \phi_a^p + \Lambda^4 \cos \frac{\phi_a}{f}$

on each branch with fixed $Q_i = \int d\theta$



- Full structure has underlying periodicity.


- Each branch has $\frac{\Delta \phi}{M_p} \gg 1$ (2008)

$$\Rightarrow r \gg 0.1 \checkmark \text{ (BICEP '14 } r \gg 0.1 \text{)}$$

On each branch :



Ranges of p, r ?

- $p < 2$ for $(d\theta + A)^2$
 \parallel
 $2 - \Delta p$ + back reaction
 $\rightarrow r \leq .15$ e.g. $\mu^3 \phi$ (uv example) 
- $2 < p < 4$? from $+ |d\theta_1 + f_0 A \wedge A|^2$
 (in progress) + back reaction
 $\rightarrow .1 < r < .26$?

Data-driven string theory phenomenology
 thanks to CMB (esp. B-mode) exp'ts.

Nonzero r at $> 5\sigma$
is a spectacular discovery

• Related to Q. Gravity / String theory

in ≥ 2 ways $\left\{ \begin{array}{l} \langle \gamma\gamma \rangle \text{ Graviton} \\ \star \langle \Delta\phi \rangle \gg M_p \end{array} \right.$

• Precise value would help e.g.
determine if $\sim m^2 \phi^2$ or
richer dynamics

• n_T , $\langle BBB \rangle$, etc. further
discrimination cf Leonardo
Talk

• TT power spectrum, TTT NG
oscillations! Flange Earth Peins...

• Relation to GUTs, SUSY, light (pseudo-)scalars
etc.