Pole N-flation

Marco Scalisi

KU LEUVEN

based on
M. Dias, J. Frazer, A. Retolaza, MS, A. Westphal - [arXiv: 1805.02659]

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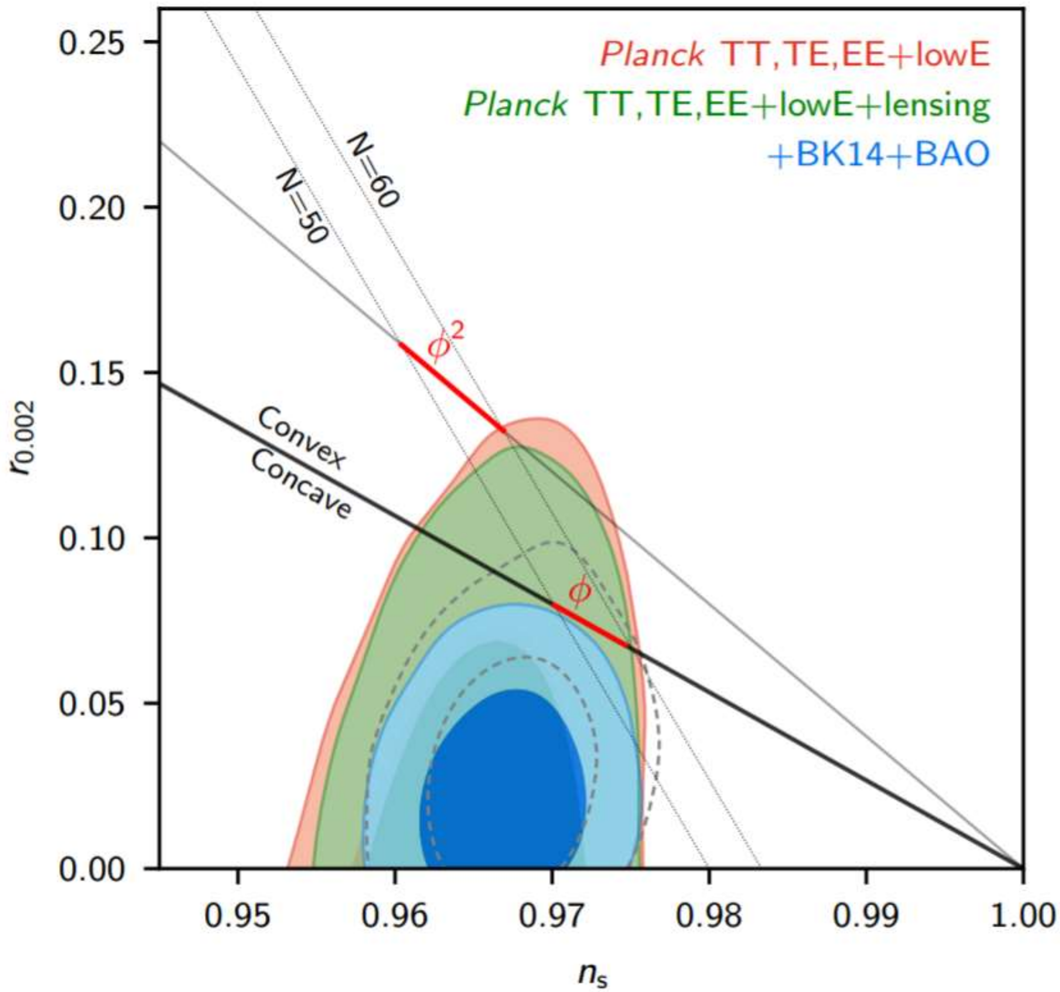
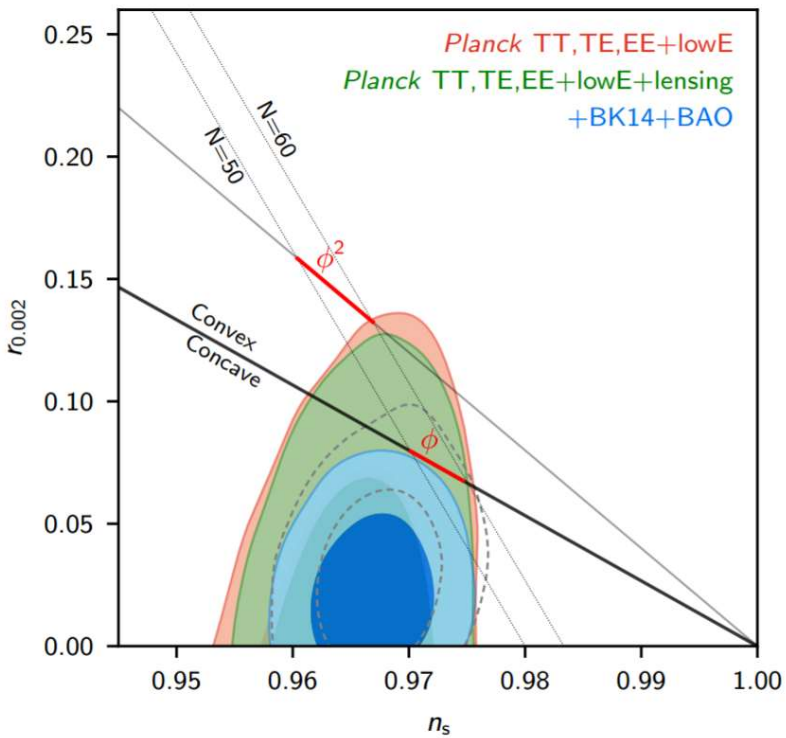
LATEST PLANCK DATA [1807.06209]



DO WE HAVE ANY SOLID THEORETICAL UNDERPINNING TO EXPLAINING WHY THE OBSERVABLES n_s AND r TAKE ON THE VALUE THEY DO?



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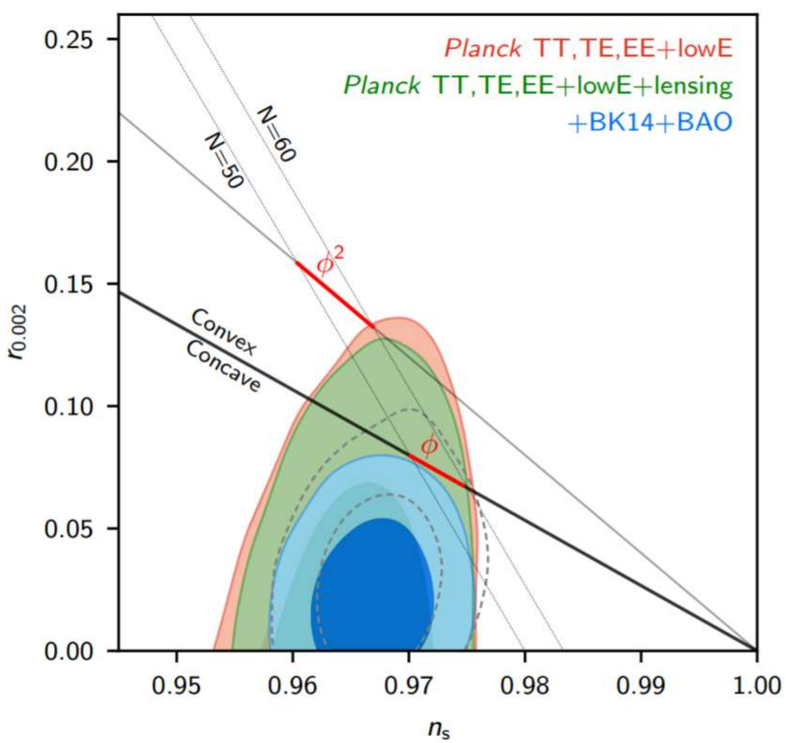
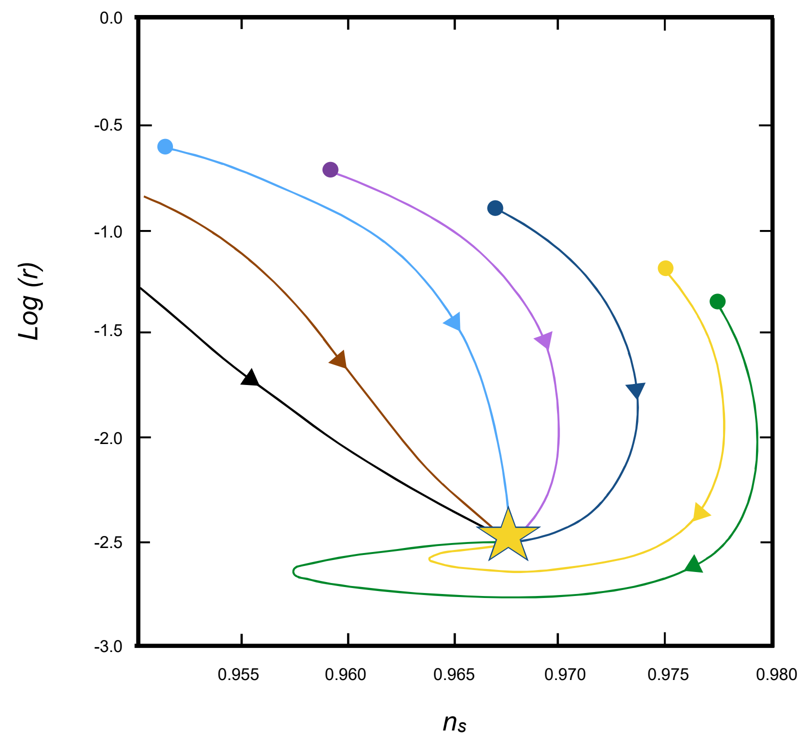
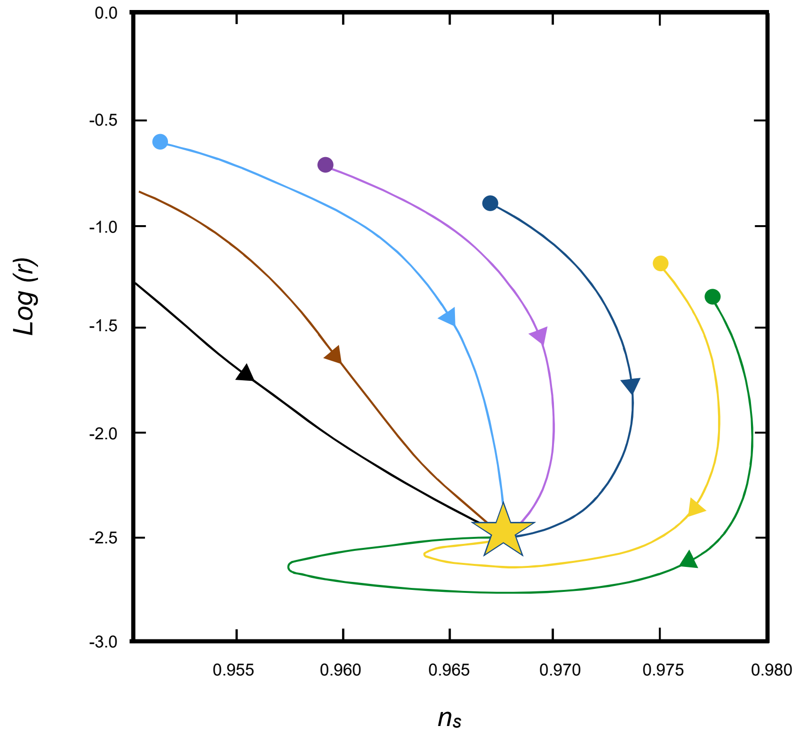


ATTRACTOR MECHANISM



non-canonical kinetic term

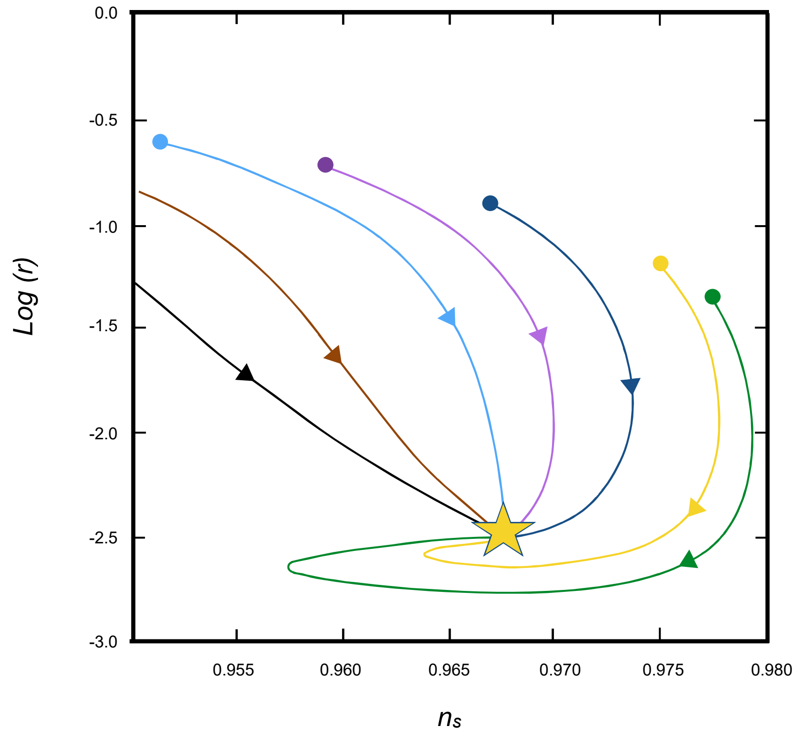
ATTRACTOR MECHANISM



non-minimal coupling to gravity

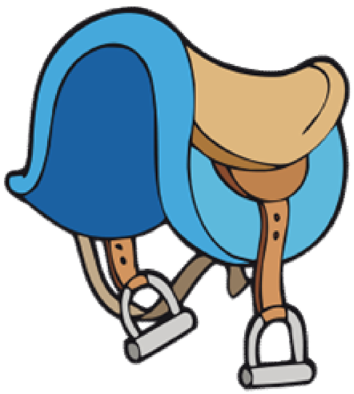
non-canonical kinetic term

ATTRACTOR MECHANISM

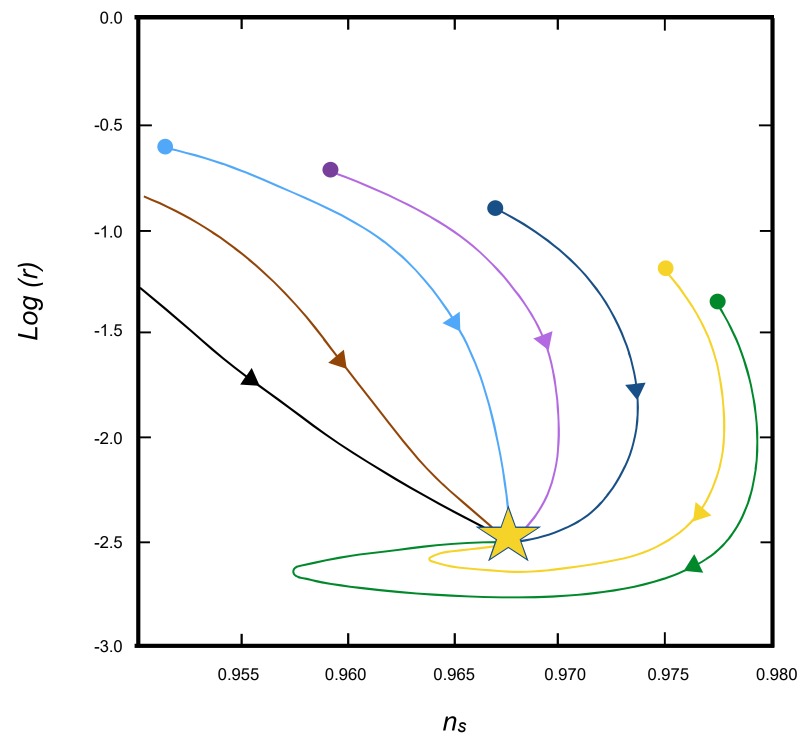


hyperbolic scalar manifold

non-minimal coupling to gravity



ATTRACTOR MECHANISM



non-canonical kinetic term

COMMON ORIGIN

"POLE INFLATION"

GALANTE, KALLOSH, LINDE, ROEST 2014

$$\mathcal{L}_{kin} = -\underbrace{\frac{3\alpha}{4\phi^2}}_{\text{POLE IN THE KINETIC TERM AS } \phi \to 0}(\partial\phi)^2$$

$$V = \underbrace{V_0}_{\text{REGULAR POTENTIAL}} - V_1\phi + O(\phi^2)$$

COMMON ORIGIN

"POLE INFLATION"

GALANTE, KALLOSH, LINDE, ROEST 2014

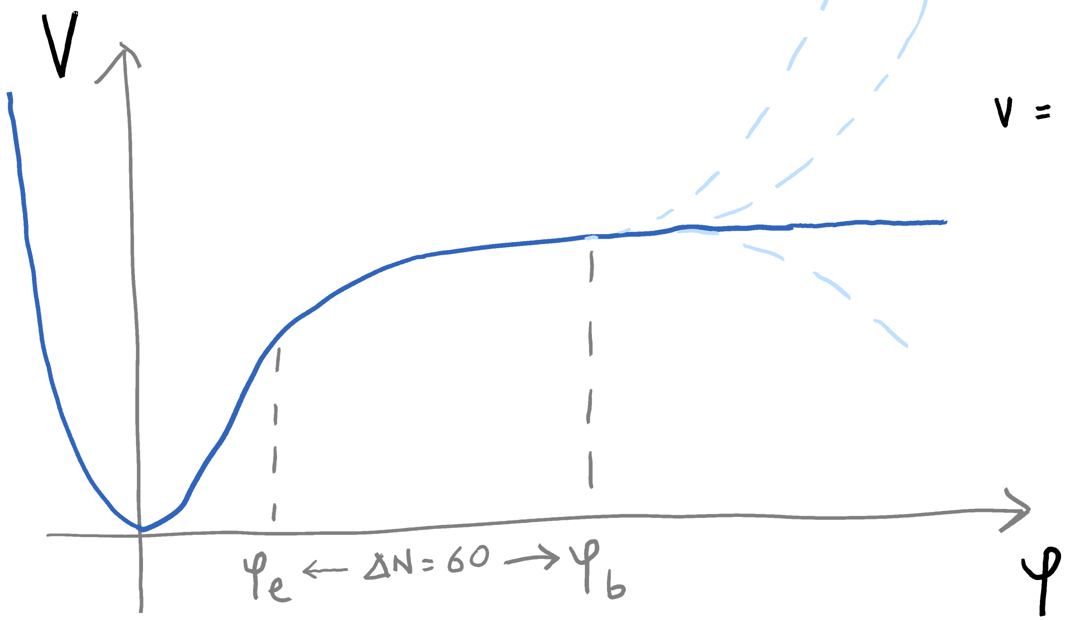
$$\varphi = \sqrt{\frac{2}{3\alpha}}\,\ln\phi$$

e.g.

FIBER INFLATION

CICOLI, BURGESS, QUEVEDO '08

$$V = V_0 + \sum_n V_n \phi^n + \sum_m V_m \frac{1}{\phi^m}$$



4D N = 1 SUPERGRAVITY

HALF PLANE COORDINATES $T+\bar{T}>0$

$$K = -3\alpha \ln\left(T+\bar{T}\right) \longrightarrow K_{T\bar{T}} = \frac{3\alpha}{(T+\bar{T})^2}$$

or

UNIT DISK COORDINATES $\phi\bar{\phi}<1$

$$K = -3\alpha \ln\left(1-\phi\bar{\phi}\right) \longrightarrow K_{\phi\bar{\phi}} = \frac{3\alpha}{(1-\phi\bar{\phi})^2}$$

4D N=1 SUPERGRAVITY

HALF PLANE COORDINATES $T+\bar{T}>0$

$$K = -3\alpha \ln(T+\bar{T}) \longrightarrow K_{T\bar{T}} = \frac{3\alpha}{(T+\bar{T})^2}$$

$$\mathcal{L}_{kin} = -\frac{3\alpha}{(T+\bar{T})^2}\partial T \partial \bar{T} = -\frac{3\alpha}{4\phi^2}\left((\partial\phi)^2 + (\partial\chi)^2\right)$$

$$T = \phi + i\chi$$

QUANTUM GRAVITY

4D EFTs

SWAMPLAND

SEE REECE'S TALK

e.g.

* NATURAL INFLATION

decay constant $f \gtrsim 5 M_p$

WGC $f \lesssim M_p$

e.g.

* NATURAL INFLATION — decay constant $f \gtrsim 5 M_p$

WGC $f \lesssim M_p$

AXION MONODROMY

MCALLISTER, SILVERSTEIN, WESTPHAL

AXION ALIGNMENT

KIM, NILLES, PELOSO

* N-FLATION — $\Delta\phi_i \sim f_i \lesssim M_p$ — $\Delta\varphi \sim \sqrt{N}\,\Delta\phi_i$

DIMOPOULOS, KACHRU, MCGREEVY, WACKER

e.g.

* NATURAL INFLATION

decay constant $f \gtrsim 5 M_P$

WGC $f \lesssim M_P$

$\sum_i f_i \leq M_P$!

* N-FLATION

$\Delta\phi_i \sim f_i \lesssim M_P$ $\Delta\varphi \sim \sqrt{N}\, \Delta\phi_i$

DIMOPOULOS, KACHRU, MCGREEVY, WACKER

QG CONSTRAINTS ON POLE INFLATION?

* INFLATION $\simeq$ NEAR KINETIC POLE $\simeq$ NEAR BOUNDARY MODULI SPACE

dangerous quantum corrections

* WGC CONSTRAINTS ON POLE INFLATION?

POLE N-FLATION

* ASSISTANCE EFFECT OF MANY FIELDS

* EACH FIELD IS INDIVIDUALLY FURTHER AWAY FROM THE BOUNDARY BY A FACTOR OF $\sqrt{N}$

$$K = -3\alpha \ln \Big(\underbrace{T + \bar{T}}_{\text{Kähler modulus}} - \sum_{i=1}^{N} a_i \underbrace{\Phi_i \bar{\Phi}_i}_{\substack{\text{open string moduli} \\ \text{e.g. D3-brane positions}}} \Big)$$

POLE N-FLATION

* ASSISTANCE EFFECT OF MANY FIELDS

* EACH FIELD IS INDIVIDUALLY FURTHER AWAY FROM THE BOUNDARY BY A FACTOR OF $\sqrt{N}$

$$K = -3\alpha \ln\left(1 - \sum_{i=1}^{N} A_i \Phi_i \bar{\Phi}_i\right)$$

N = 2 and
ϕ_i not complex
SEE
E. SFAKIANAKIS' TALK

pole at $R^2 \equiv \sum_k A_k \Phi_k \bar{\Phi}_k = 1$

POLE N-FLATION

$$\phi_i = \frac{R}{\sqrt{A_i}} \underbrace{\Omega_i}_{\text{}} (\psi_\beta)\, e^{i\theta_i}$$

θ_i AXIONIC VARIABLES

SPHERICAL ANGULAR ELEMENT $\quad \sum_i \Omega_i^2 (\psi_\beta) = 1 \quad , \beta = 1, \dots, N-1$

POLE N-FLATION

$$\phi_i = \frac{R}{\sqrt{A_i}} \underbrace{\Omega_i(\psi_\beta)}_{\text{SPHERICAL ANGULAR ELEMENT}} e^{i\theta_i}$$

θ_i AXIONIC VARIABLES

$$\sum_i \Omega_i^2(\psi_\beta) = 1 \quad , \; \beta = 1, \dots, N-1$$

KINETIC TERM

$$-3\alpha \left[\frac{\partial R \, \partial R}{(1-R^2)^2} + \frac{R^2}{1-R^2} \sum_i (\partial_\beta \Omega_i)^2 \partial \psi_\beta \partial \psi^\beta + \sum_{ij} G_{ij} \, \partial \theta_i \, \partial \theta_j \right]$$

$$G_{ij} = \frac{R^4}{(1-R^2)^2} \Omega_i^2 \Omega_j^2 + \frac{R^2}{1-R^2} \delta_{ij} \Omega_i^2$$

* INDEPENDENT OF θ_i

* DIAGONAL IN R AND ψ_β

Pole N-flation

$$-3\alpha\left[\frac{\partial R\,\partial R}{(1-R^2)^2}+\frac{R^2}{1-R^2}\sum_i(\partial_\beta\Omega_i)^2\,\partial\psi_\beta\,\partial\psi^\beta+\sum_{ij}G_{ij}\,\partial\theta_i\,\partial\theta_j\right]$$

$$R=\tanh\frac{\varphi}{\sqrt{6\alpha}}$$ with φ CANONICAL VARIABLE

$$V=\sum_{i,j,p\geq 1} b_{ijp}\left(\phi_i\bar{\phi}_j+cc\right)^p$$

Pole N-flation

$$-3\alpha\left[\frac{\partial R\,\partial R}{(1-R^2)^2}+\frac{R^2}{1-R^2}\sum_i\left(\partial_\beta\Omega_i\right)^2\partial\psi_\beta\,\partial\psi^\beta+\sum_{ij}G_{ij}\,\partial\theta_i\,\partial\theta_j\right]$$

$$R=\tanh\frac{\varphi}{\sqrt{6\alpha}}$$ with φ CANONICAL VARIABLE

$$n_s=1-\frac{2}{N}$$

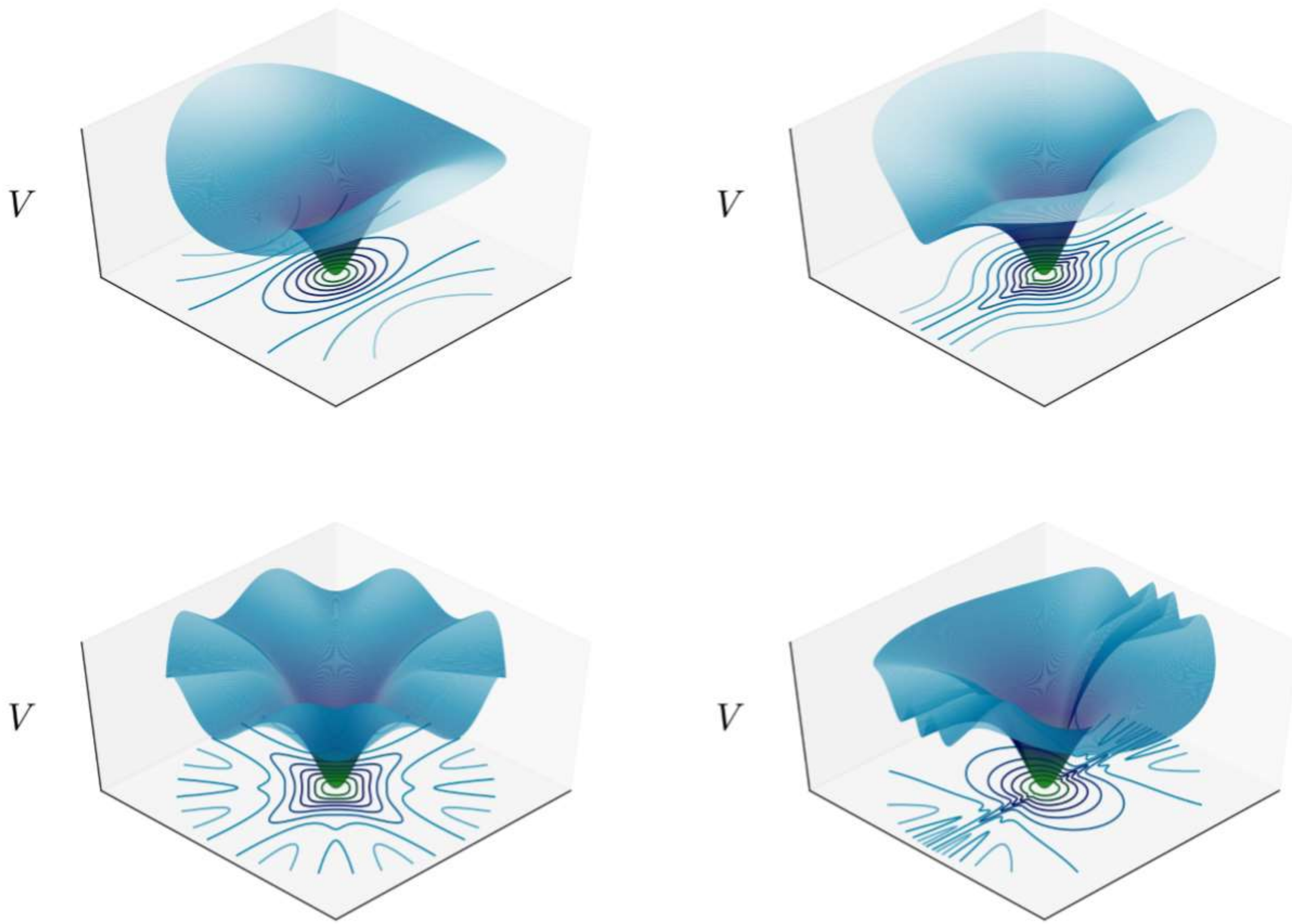
$$r=\frac{12\alpha}{N^2}$$

$$V=\sum_{i,j,p\geq 1}b_{ijp}\left(\phi_i\bar{\phi}_j+cc\right)^p$$

$$\Longrightarrow\quad V=V_0(\theta_i,\psi_\beta)-e^{-\sqrt{\frac{2}{3\alpha}}\varphi}\,V_1(\theta_i,\psi_\beta)+\dots$$

POLE N-FLATION

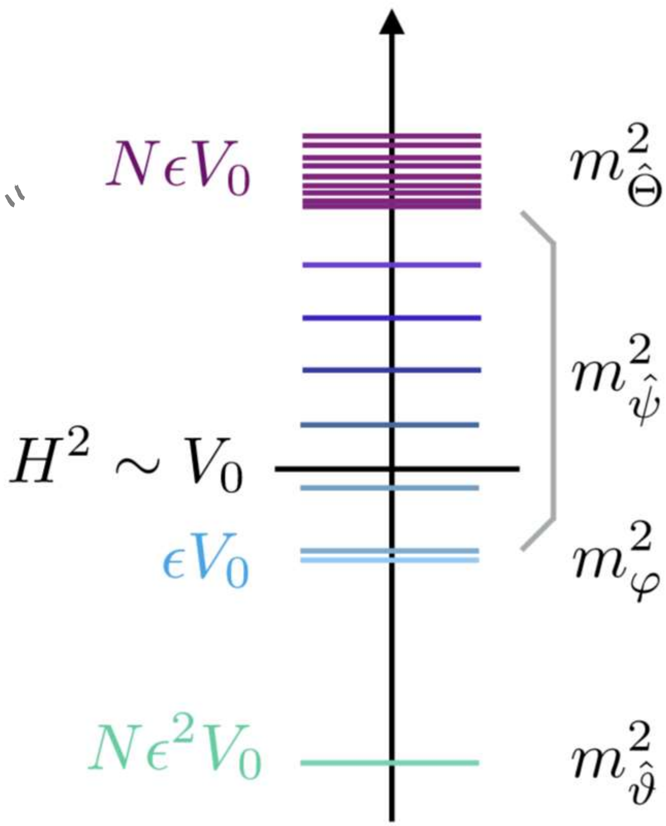
$N = 2 \quad \{\varphi, \psi\}$



POLE N-FLATION – MASSES HIERARCHY

$R \equiv 1 - \epsilon$

"PROXIMITY TO THE POLE"



N - 1 axions

N - 1 angular variables

radial direction

single axion

"ROLLING ON THE RIDGE"

ACHÚCARRO, KALLOSH, LINDE, WANG, WELLING 2017

WGC CONSTRAINTS

$\boxed{N=1}$ decay constant of the axion $f^2(\phi) = \dfrac{6\alpha\phi^2}{(1-\phi^2)^2}$

first slow-roll parameter $\epsilon \simeq \dfrac{(1-\phi^2)^2}{3\alpha\phi^2} < 1$ DURING INFLATION

$$\Longrightarrow \quad f^2(\phi) \gtrsim \mathcal{O}(1)$$

NOT ENOUGH INFLATION!

WGC CONSTRAINTS

POLE N-FLATION

$$\sum_i f_i = \underbrace{\frac{1}{N}\left(\frac{6\alpha R^2}{(1-R^2)^2} - \frac{6\alpha R^2}{(1-R^2)}\right)}_{} + \frac{6\alpha R^2}{1-R^2} > 1$$

TO HAVE ENOUGH INFLATION

at large N

JUST THIS PIECE IS SUPPRESSED

CONCLUSIONS

* POLE INFLATION / α-ATTRACTORS GIVES A GREAT MATCH WITH COSMOLOGICAL DATA
* POLE N-FLATION ALLEVIATES THE EXPECTED PROBLEMS WITH QUANTUM CORRECTIONS
* POLE N-FLATION MIGHT FURNISH GREAT MULTIFIELD PHENOMENOLOGY ---> MASS HIERARCHY
* WGC CONSTRAINS BOTH POLE INFLATION / N-FLATION

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thanks!
감사합니다

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