# Chaotic Inflation in Supergravity with Heisenberg Symmetry

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Based on: Physics Letters B 679 (2009) 428-432
arXiv: 0905.0905 (Antusch, Bastero-Gil, Dutta, King, PMK)


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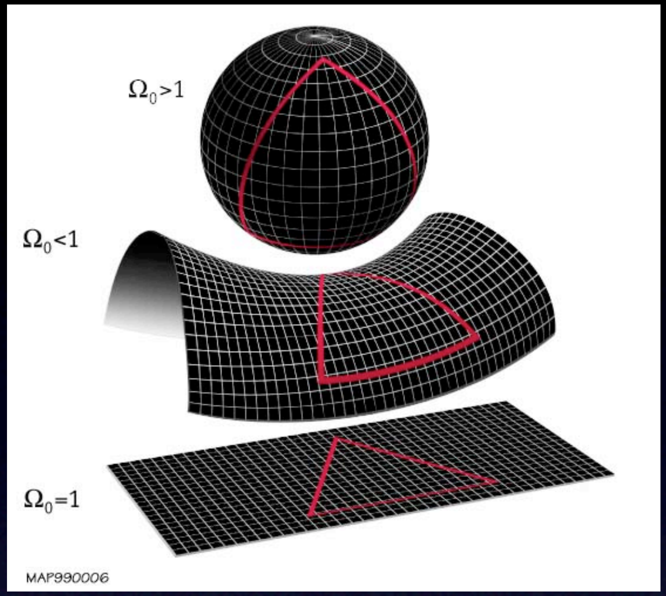
# Outline

- Chaotic inflation on two slides
- 2 generic problems in SUGRA
- Our framework with a Heisenberg symmetry
- Scalar potential with problems resolved
- Summary

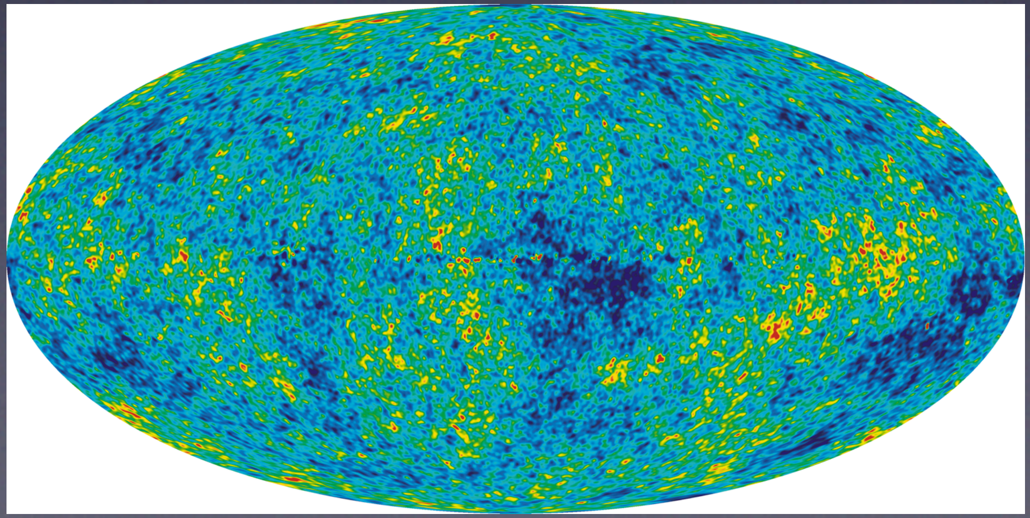
# Generic Predictions:

- Spatially flat $\ddot{a} > 0$
- Homogeneous, isotropic
- Absence of relic species




# Model-dependent:

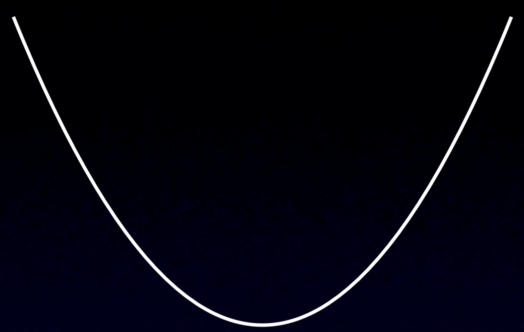
- Spectrum of primordial perturbations



$$P_{\mathcal{R}}(k) = P_{\mathcal{R}}(k_0) \left(\frac{k}{k_0}\right)^{n_s - 1}$$

$$r = P_{\mathcal{T}}/P_{\mathcal{R}}$$

Large field



Small field

Inflation model = Scalar potential

$$V(\phi) \gg \dot{\phi}^2/2$$

Slow-roll approximation

$$\epsilon = \frac{1}{2}\left(\frac{V'}{V}\right)^2 \ll 1$$

$$|\eta| = \left|\frac{V''}{V}\right| \ll 1$$

Observables in power spectra

$$(P_{\mathcal{R}}, n_{\rm s}, r, \ldots)$$

can be related to scalar potential

# The η-Problem

- Effective field theory: Singlet inflaton, not forbidden

$$V(\phi)\left[\frac{\bar{\phi}\phi}{M_{\mathrm{P}}^2}+\mathcal{O}\left((\bar{\phi}\phi)^2\right)\right]$$

- Slow-roll conditions violated, large curvature: $\eta \sim 1$

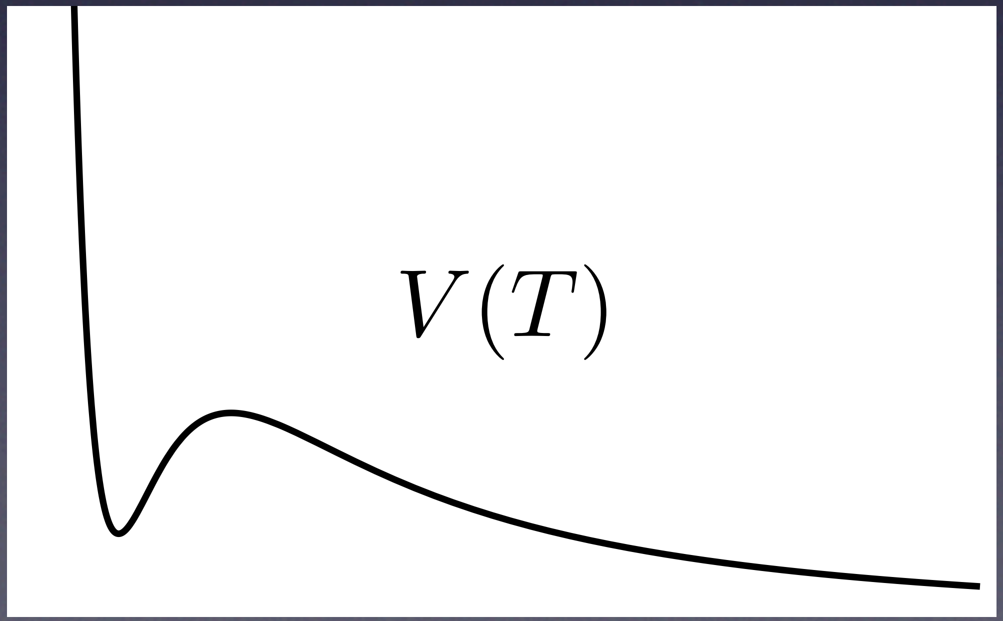
**Supergravity:** $V_F = \mathrm{e}^K \left( K^{i\bar{j}} D_i W \, D_{\bar{j}} \bar{W} - 3\,|W|^2 \right)$

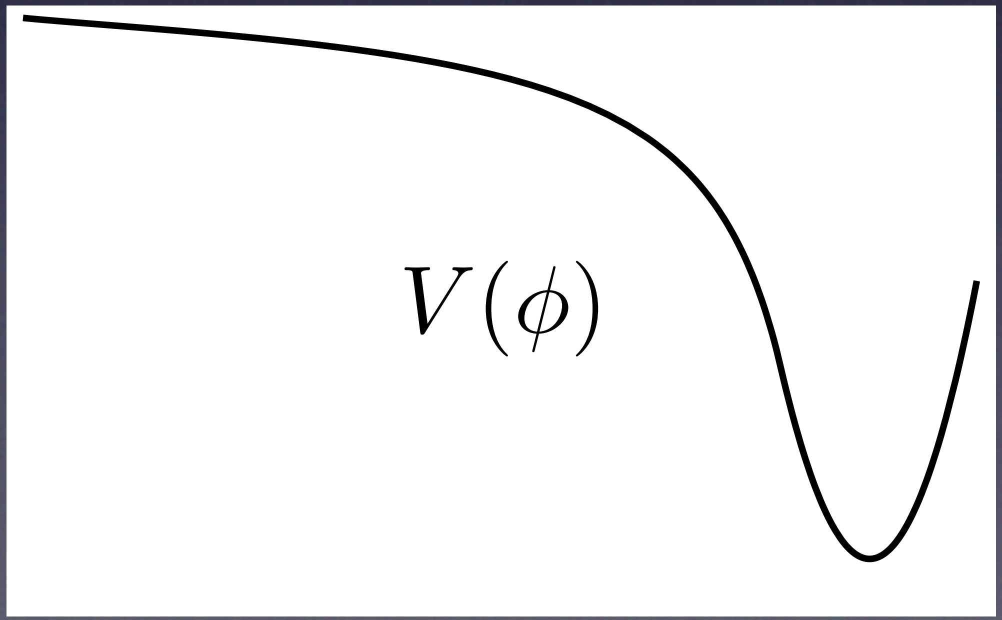
F-term potential generically plagued

# Moduli Problem

(Brustein, Steinhardt; Dine)

- Additional scalar fields
- Minimum and mass larger than Hubble scale
- Opposite requirements for moduli and inflaton




(Kachru, Kallosh, Linde, Trivedi)

# Roads to Solutions

- Expansion of Kähler
- Tune parameters
- Large field problematic

$$K = |\phi|^2 + \alpha \frac{|\phi|^4}{M_{\mathrm{P}}^2} + \ldots$$

- Symmetry in Kähler
- New degree of freedom
- 'Hide' inflaton direction

$$K = K(\rho)$$

Reminder: $V_F \sim V_0 \cdot \mathrm{e}^K$

in shift symmetry context see (Kawasaki, Yamaguchi, Yanagida)

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# Roads to Solutions

Heisenberg symmetry:

$$T \longrightarrow T + \mathrm{i}\,\mu$$

$$T \longrightarrow T + \alpha^* \Phi + \frac{|\alpha|^2}{2}$$

$$\Phi \longrightarrow \Phi + \alpha$$

Invariant combination:

$$\rho = T + T^* - |\Phi|^2$$

Reminder: $V_F \sim V_0 \cdot \mathrm{e}^K$

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$$K = K(\rho)$$

in shift symmetry context see
(Kawasaki, Yamaguchi, Yanagida)

# Our Framework

$$\rho = T + T^* - |\Phi|^2$$

Heisenberg breaking superpotential

Heisenberg invariant Kähler potential

$$W = M\,\Phi\,X \qquad K = |X|^2 + \kappa_X |X|^4 + \kappa_\rho\,\rho\,|X|^2 + f(\rho)$$

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F-term of X provides vacuum energy

provides large X mass

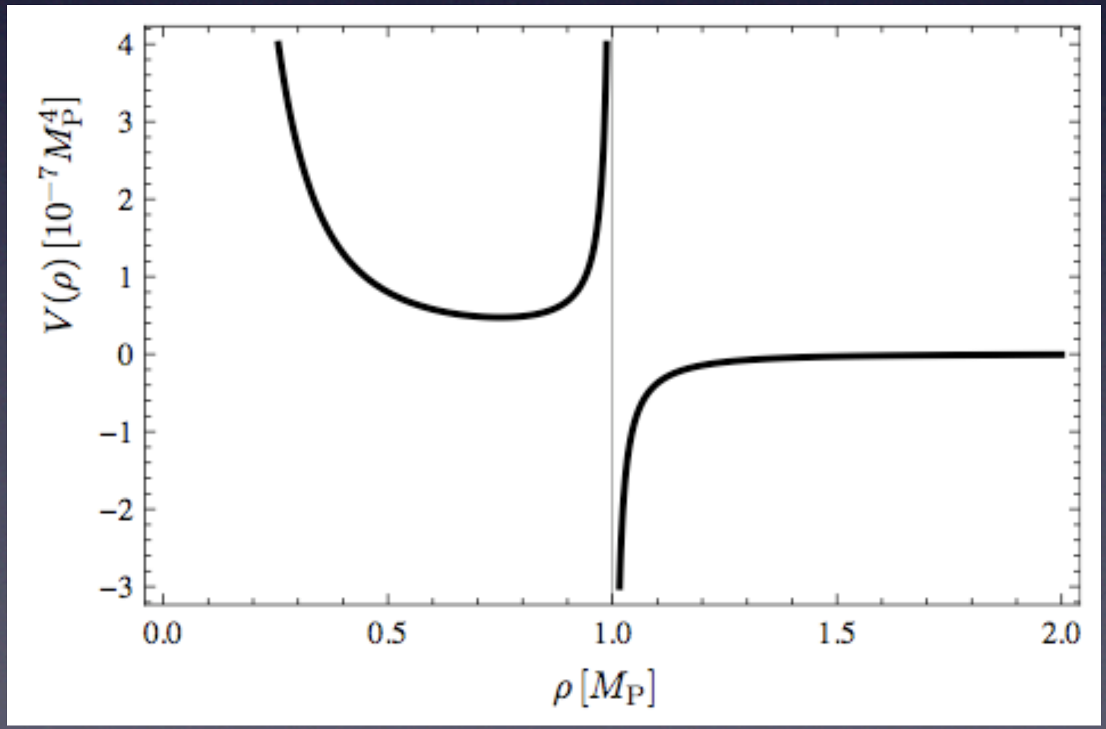
generates modulus stabilizing potential

$$f(\rho) = -3\ln\rho$$

# Scalar Potential

$$V_F = \frac{M^2|\phi|^2}{\rho^3(1+\kappa_\rho \rho)}$$

- Modulus stable: minimum, very heavy

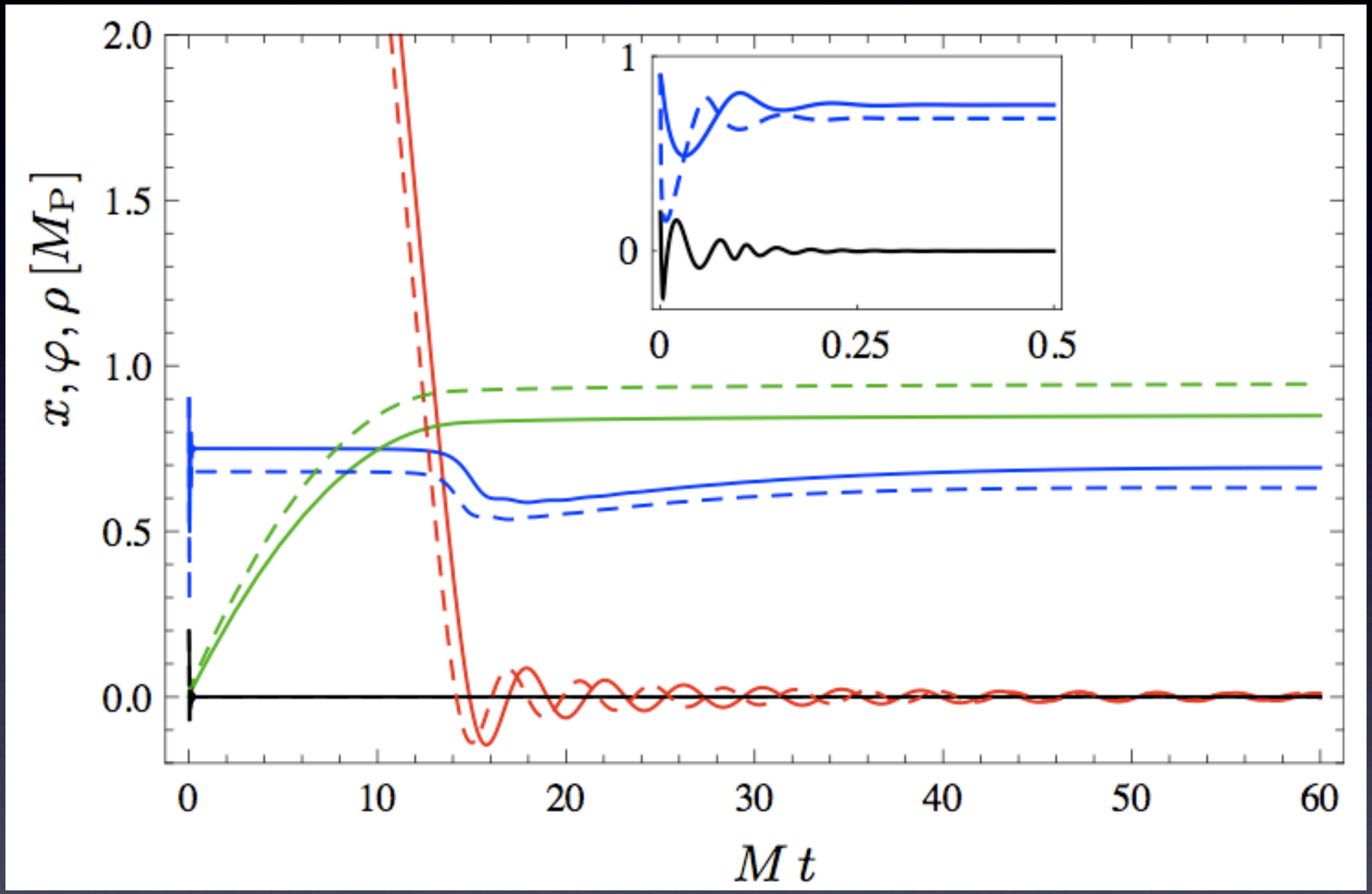



$$m_\rho \sim M\,|\phi| \gg H$$

- η-problem solved: tree-level quadratic
- Normalization of the power spectrum gives $M \sim 10^{-5} M_{\rm P}$

$$m_\phi \sim M \ll H$$

# Scalar Field Dynamics

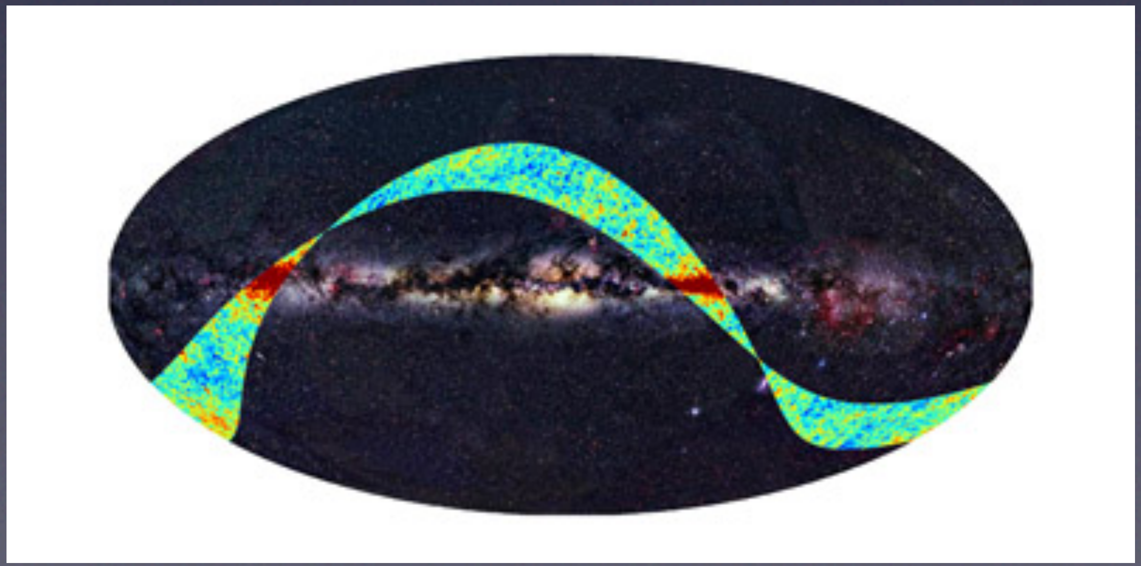



- Modulus settles quickly, inflaton slow-rolls
- Universe inflates sufficiently

# Summary

- Chaotic inflation model in SUGRA
- Heisenberg symmetry solves η-Problem
- Modulus stabilized by large vacuum energy
- Tree-level quadratic potential from Heisenberg symmetry breaking superpotential
- Generic predictions:

$n_{\mathrm{s}} \sim 0.97 \qquad r \sim 0.13$



[Image: esa]