Horizon Feedback Inflation

arXiv:1712.07977

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Inflation

- Inflation helps to explain the Horizon and Flatness problem and seeds the perturbations to explain structure formation

- Inflation requires a period of de-Sitter expansion

- In field theory inflation is driven by the inflaton field

    - *What are the initials conditions to get our observable universe? and why those?*

Gibbons-Hawking temperature

- Temperature associated with the cosmological horizon in de-Sitter space

$$T_H = \frac{H}{2\pi}$$

- *"An observer with a particle detector will indeed observe a background of thermal radiation coming apparently from the cosmological event horizon"[1]*

- Source of quantum fluctuations in the inflaton field

- It might create a non-negligible finite temperature correction to the potential energy of the inflaton

[1] G. W. Gibbons and S. W. Hawking, Cosmological Event Horizons, Thermodynamics, and Particle Creation , Phys. Rev. D15 (1977) 2738-2751.

Our model

Friedman equations:

$$3H^2 M_P^2 = \rho \qquad\qquad -(3H^2 + 2\dot{H})M_P^2 = p$$

T. Markkanen, De Sitter Stability and Coarse Graining , arXiv:1703.06898 .

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Dynamics

- Dynamical mass-> change the shape of the potential

$$m^2 = Ng^2T_H^2 - \lambda\varphi_0^2$$

$$m^2 \gtrsim 0 : \text{gradual decay of } \rho_\Lambda$$

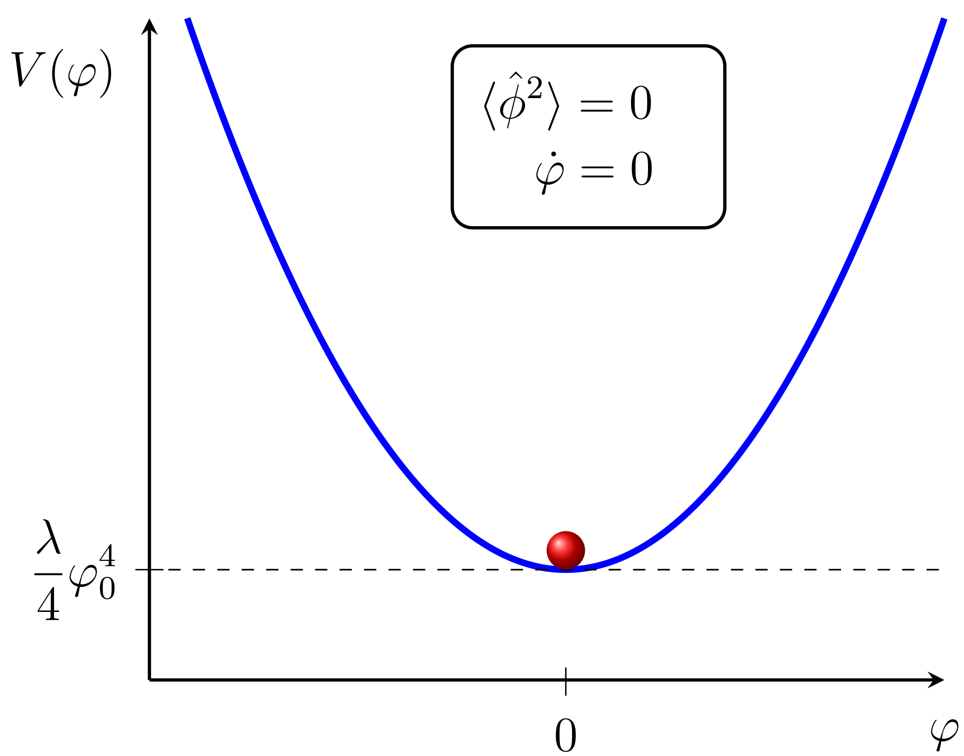
$$m^2 \sim 0 : \text{large quantum fluctuations}$$

$$m^2 \lesssim 0\text{: classical rolling}$$

Dynamics

$$m^2 \gtrsim 0 : \text{gradual decay of } \rho_\Lambda$$

$$H \simeq \sqrt{\frac{\lambda}{12}}\frac{(\varphi_0)^2}{M_P}$$



Decay Cosmological vacuum:
de-Sitter spacetime with particle production is not stable

$$-2\dot{H}M_P^2 = \dot{\varphi}^2 + \frac{4}{3}N\frac{\pi^2}{30}T_H^4$$

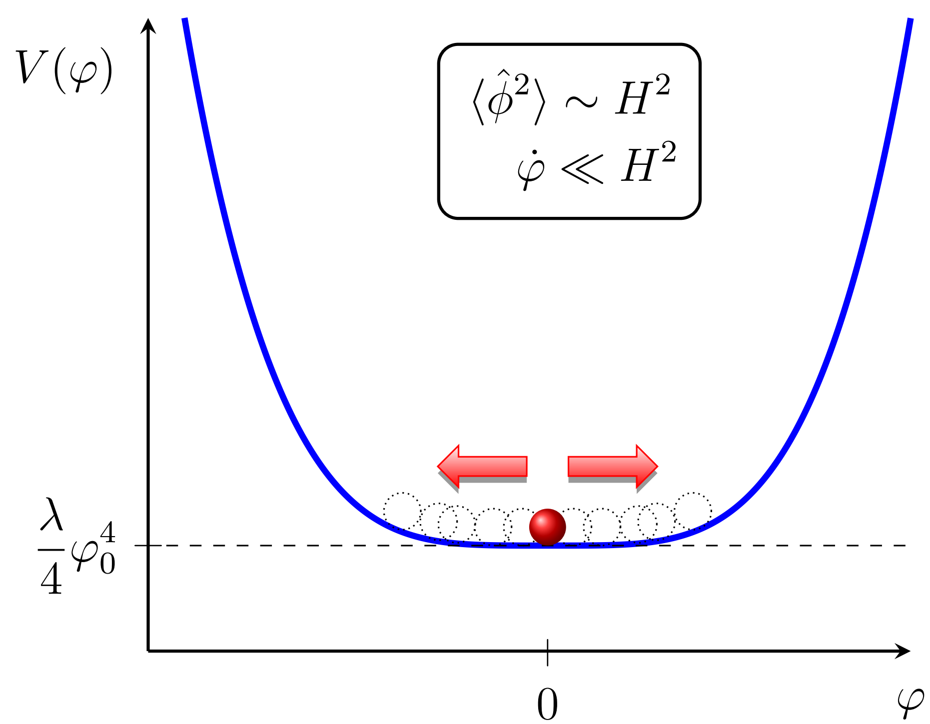
$$\epsilon = -\frac{\dot{H}}{H^2} = \frac{NH^2}{720\pi^2 M_P^2}$$

Symmetry breaking
(m=0)

$$\frac{(\varphi_0)_{\text{SB}}}{M_P} = \frac{4\pi\sqrt{3}}{\sqrt{N}g}$$

Dynamics

$$m^2 \sim 0 : \text{large quantum fluctuations}$$



Hartree approximation

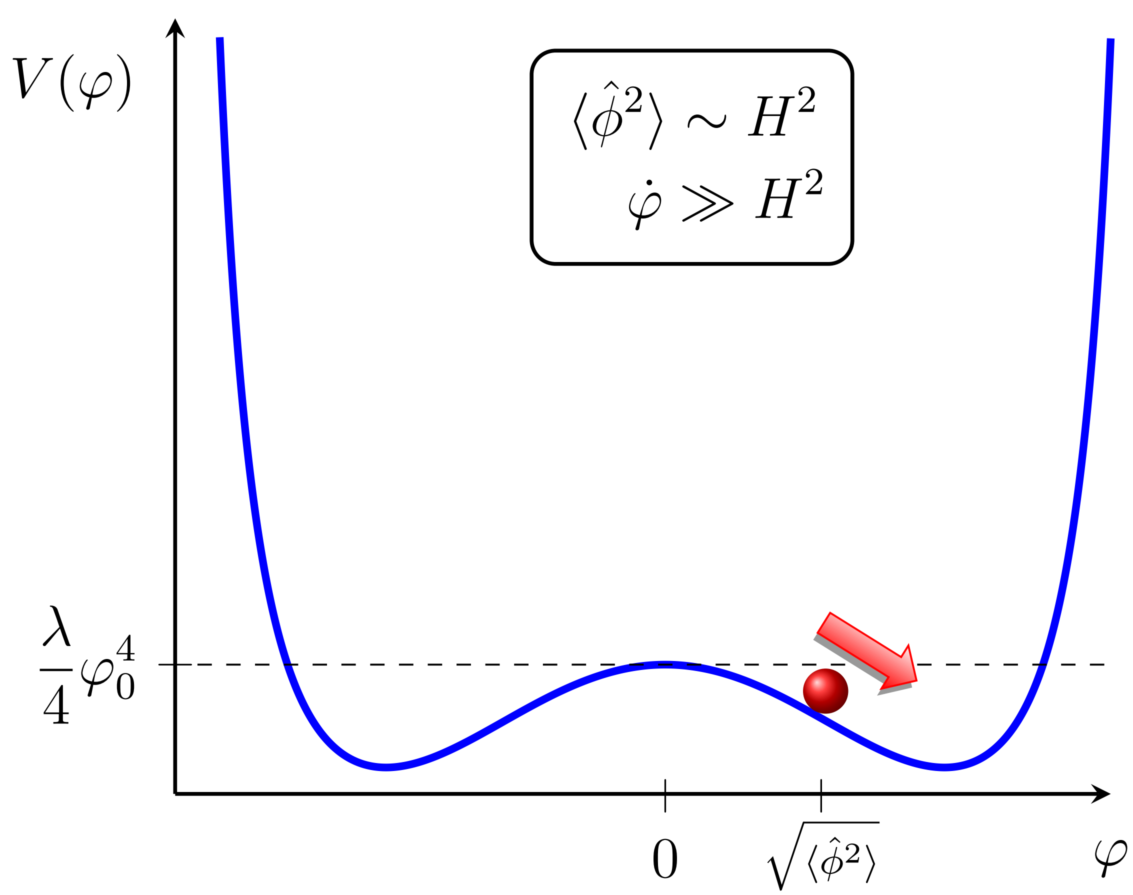
$$\frac{d}{dt}\langle \hat{\phi}^2 \rangle = \frac{H^3}{4\pi^2} - \frac{2m^2}{3H}\langle \hat{\phi}^2 \rangle - \frac{2\lambda}{H}\langle \hat{\phi}^2 \rangle^2$$

$$\langle \hat{\phi}^2 \rangle \overset{m \to 0}{=} \frac{H^2}{\pi\sqrt{8\lambda}}$$

Quantum to classical transition at the inflection point $\longrightarrow$ $-m^2 \simeq 3\lambda \langle \hat{\phi}^2 \rangle = 3\lambda \frac{H^2}{\pi\sqrt{8\lambda}}$

Dynamics

$m^2 \lesssim 0$: classical rolling



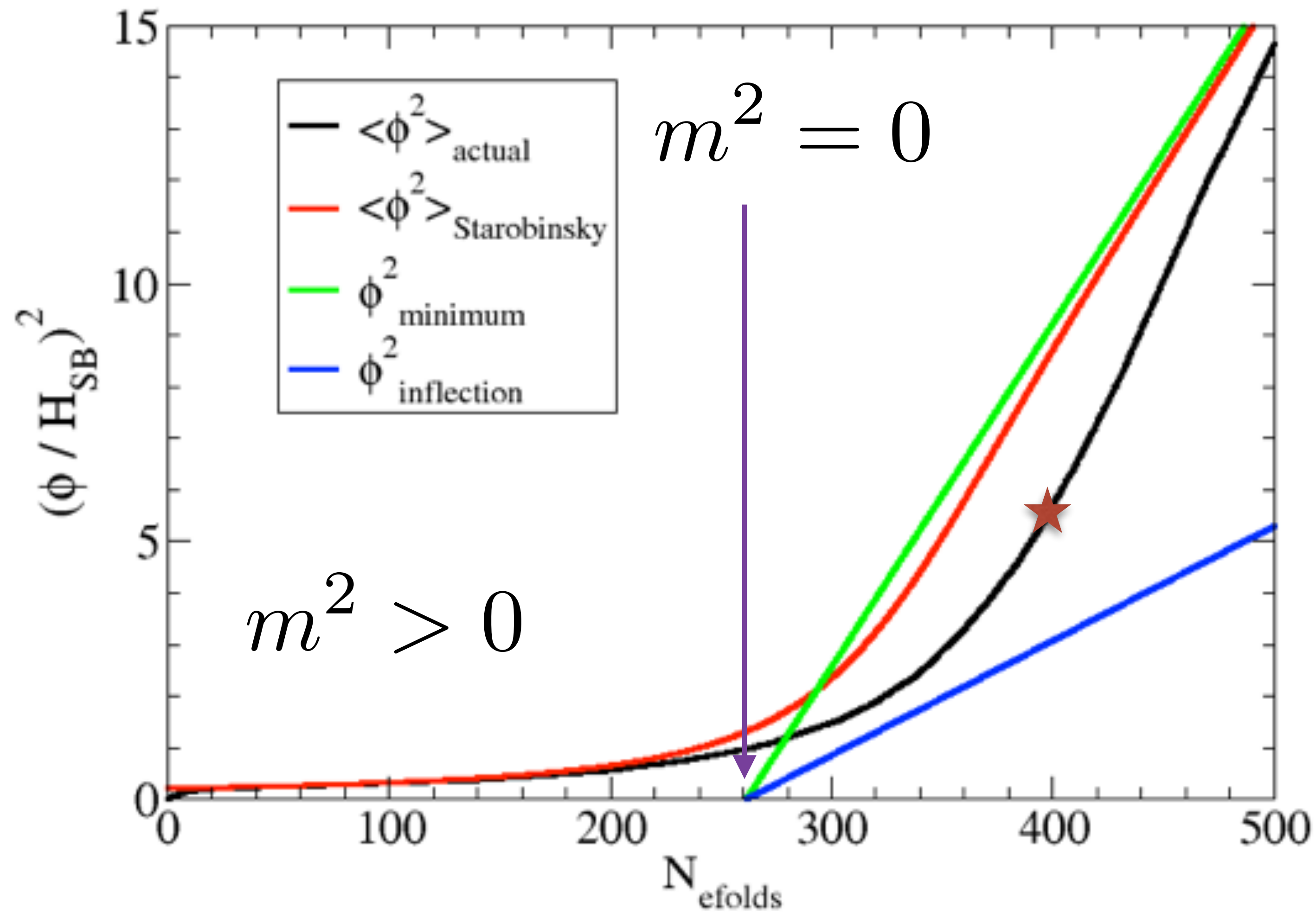
Initial conditions set dynamically

$$\frac{d}{dN_e}\langle\hat{\phi}^2\rangle = \left(\frac{H}{2\pi}\right)^2$$

$$\langle\hat{\phi}^2\rangle = \frac{H^2}{\pi\sqrt{8\lambda}} = \frac{-m^2}{3\lambda}$$

Dynamics-numerics

Langevin equation: $$\frac{d\varphi}{dN_e} = -\frac{m^2\varphi + \lambda\varphi^3}{3H^2} + \frac{H}{2\pi}\xi$$



For the parameters:

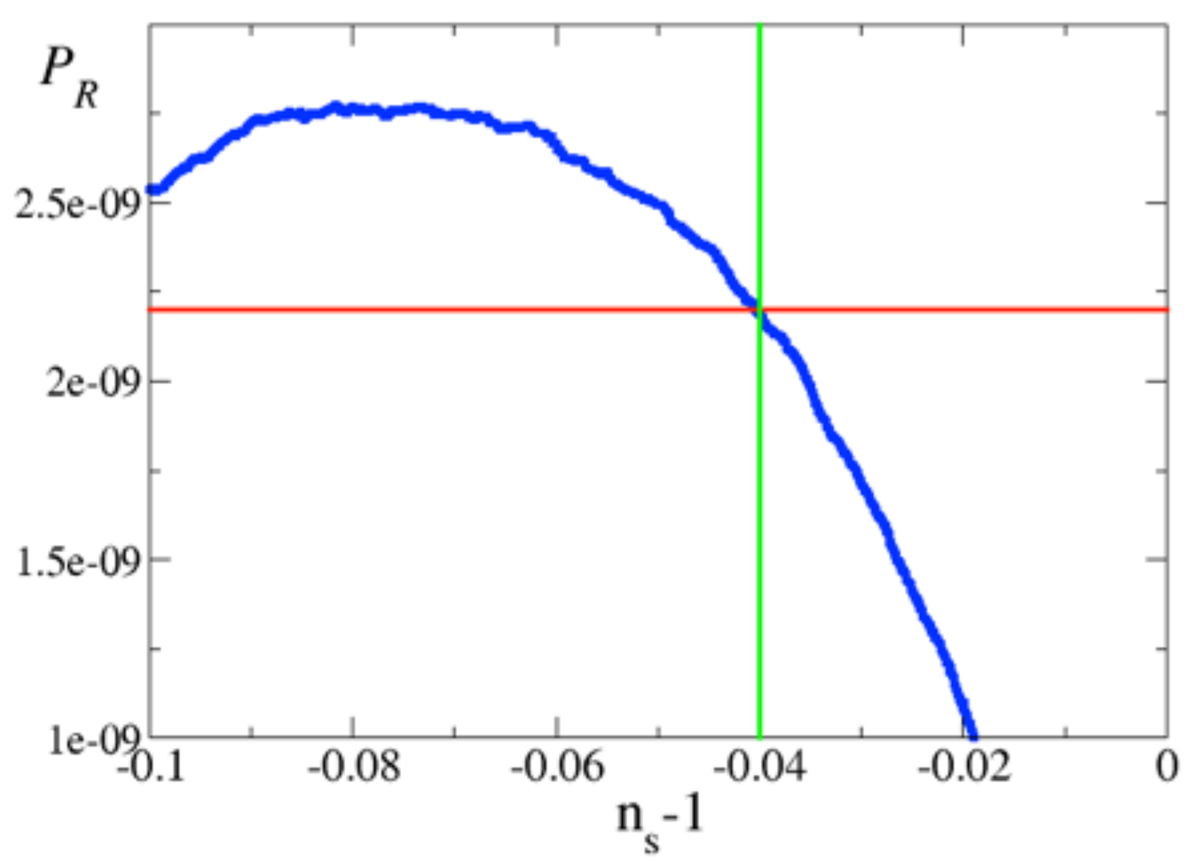
$\lambda = 10^{-2}, N = 10^{5.5},$ and $g = 1$

(making $\varphi_0 = 10^{-1.41} M_P$)

Inflationary predictions

$$\mathcal{P}_{\mathcal{R}} = \frac{2025}{\sqrt{2}\pi}\left(- \alpha + \frac{\alpha^3}{3}\right)^2 \frac{\sqrt{\lambda}}{N^2}$$

$$n_s - 1 = \frac{-1+\alpha^2}{\sqrt{2}\pi}\sqrt{\lambda}$$



$$\alpha = \frac{\varphi}{\sqrt{-m^2/3\lambda}}$$

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Summary

- Extremely slow symmetry breaking, allow inflates hilltop potentials that without this temperature correction couldn’t give you enough e folds of inflation

- No super Planckian values of the Inflaton

- No fine tune parameters, “natural” choice of parameters

- No need to set up initial conditions

- Obtain the correct perturbations and spectral tilt

- Need to end inflation by making the spectator fields heavy