Cosmology Final Report

Allen Huang

National Tsing Hua University

December 25, 2018

Overview

What is inflation?

Why we need inflation?

- Horizon problem
  Every part of sky is seem to be in thermal equilibrium
- Flatness problem
  $\Omega - 1 \propto a^{-2}$
- monopole problem
  Magnetic monopole is extremely rare in the universe

Inflaton

- Scalar(spin 0) particle, inflaton(ϕ).
- Lagrangian $L = -\frac{1}{2} g^{\mu\nu} \partial_\mu \phi \partial_\nu \phi - V(\phi)$
- Field equation

$$\ddot{\phi} - \nabla^2 \phi + \frac{\partial V}{\partial \phi}$$

Dynamics

- energy density $\rho_\phi = \frac{1}{2}\dot{\phi}^2 + V(\phi)$
- pressure $P_\phi = \frac{1}{2}\dot{\phi}^2 - V(\phi)$

The combine these euqations with Friedmann equations and continuity equations

$$H^2 = \frac{1}{3M_{Pl}^2}\left[V(\phi) + \frac{1}{2}\dot{\phi}^2\right]$$

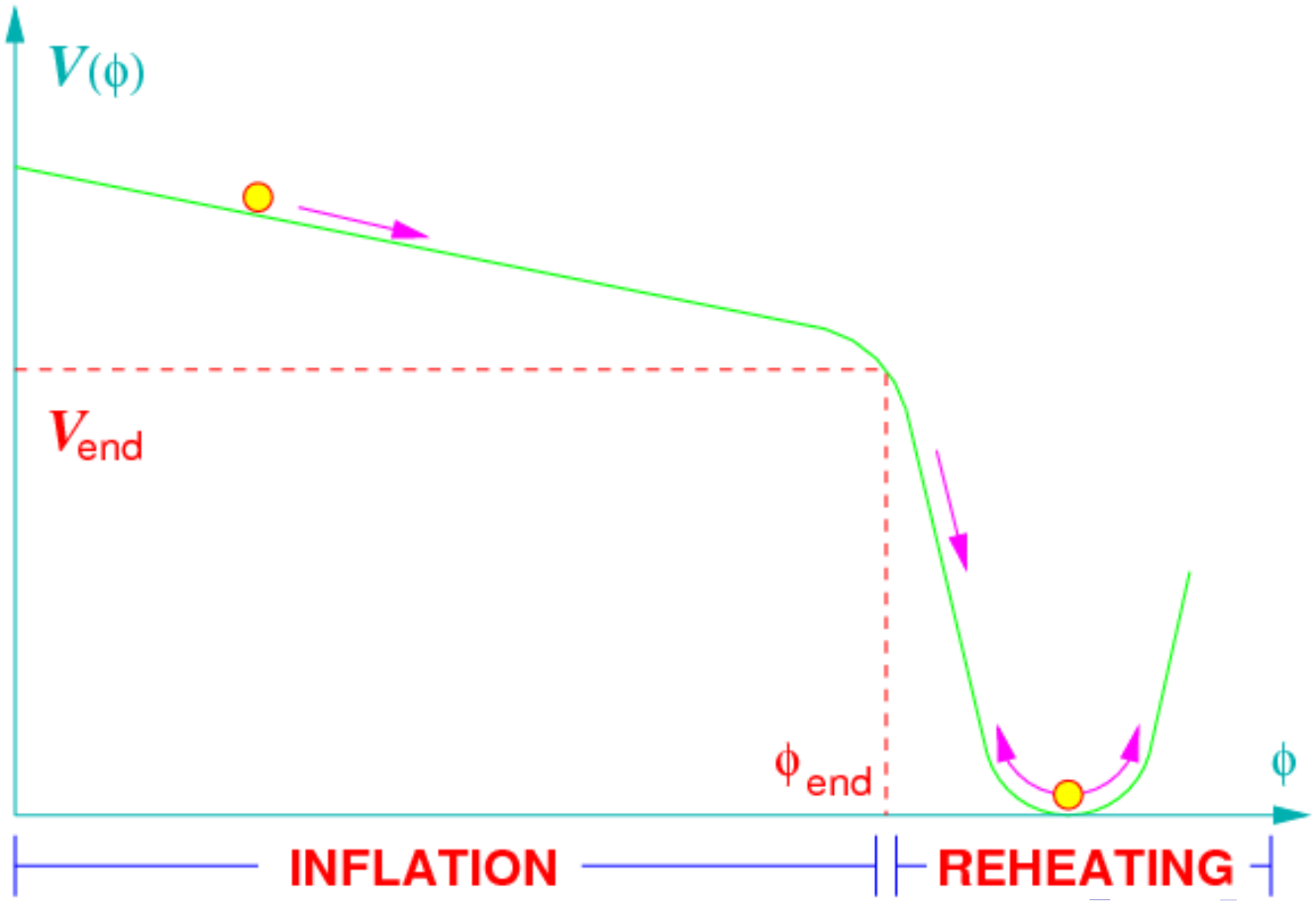
and

$$\ddot{\phi} + 3H\dot{\phi} = -\frac{dV}{d\phi}$$

Slow-roll inflation

Assuming $\dot{\phi}$ is pretty small(slow-roll approximation)

$$H^2 \approx \frac{V(\phi)}{3M_{Pl}^2}, \quad 3H\dot{\phi} \approx -V'(\phi)$$



Slow-roll inflation

slow-roll approximation

$$\Rightarrow H = \frac{\partial \ln(a)}{\partial t} = \dot{\phi}\partial_\phi \ln(a) \approx -\frac{\partial_\phi V}{3H}\partial_\phi \ln(a)$$

$$\Rightarrow H^2 \approx \frac{1}{3}V \approx \frac{1}{3}\partial_\phi V \partial_\phi \ln(a)$$

$$\Rightarrow \partial_\phi \ln(a) \approx \frac{V}{\partial_\phi V} = (\partial_\phi \ln(V))^{-1}$$

$$\Rightarrow a = a_0 e^{\int d\phi \left(\partial_\phi \ln(V)\right)^{-1}}$$

Starobinsky inflation

The action

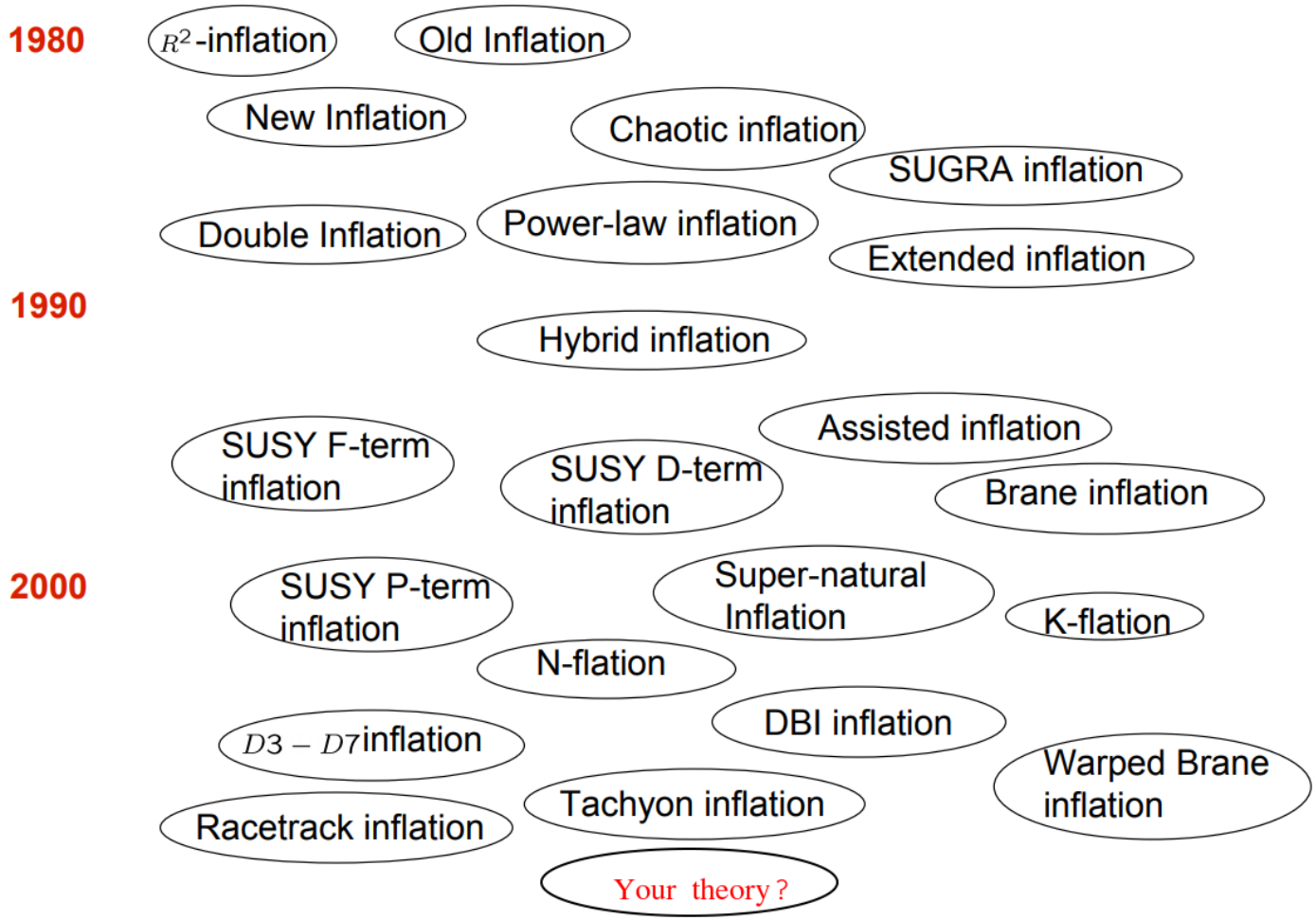
$$S = \frac{1}{2}\int d^4x\sqrt{-g}\left(R - \frac{R^2}{6m^2}\right)$$

m is a mass-dimensional parameter(actually the inflaton mass)
The corresponding potential in Einstein frame

$$V(\phi) = \frac{3}{4}m^2\left(1 - e^{-\sqrt{2/3}\phi}\right)^2$$

This resolved the cosmology problems and led to specific predictions for the corrections to the microwave background radiation, corrections that were then calculated in detail.

What's more?


1980
R^2-inflation
Old Inflation
New Inflation
Chaotic inflation
SUGRA inflation
Double Inflation
Power-law inflation
Extended inflation
1990
Hybrid inflation
Assisted inflation
SUSY F-term inflation
SUSY D-term inflation
Brane inflation
2000
SUSY P-term inflation
Super-natural Inflation
K-flation
N-flation
DBI inflation
$D3-D7$inflation
Warped Brane inflation
Tachyon inflation
Racetrack inflation
Your theory ?