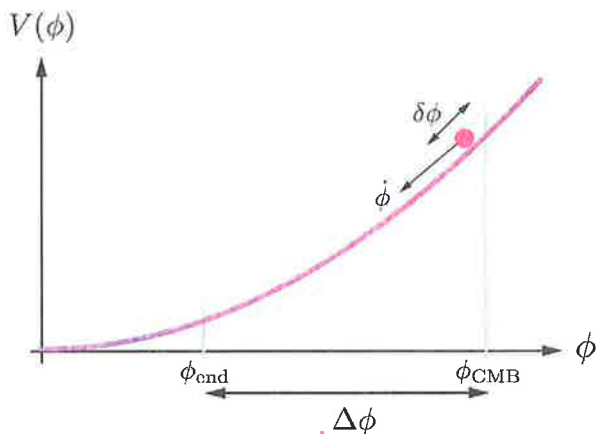


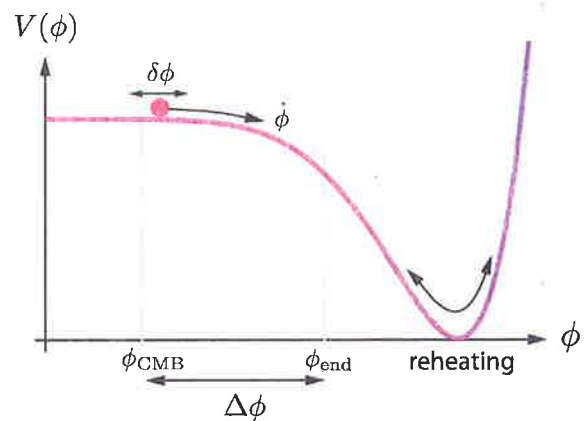
# Classifying inflationary models

Roughly speaking: ``Large field'' models can produce a high level of gravity waves;  
 ``small field'' models produce a low level of gravity waves

$$r = \frac{\mathcal{P}_T}{\mathcal{P}_\zeta} = \epsilon$$



``Large field'' like potential



``Small field'' like potential  
 predict  $\epsilon$  very very small

## Why gravity waves of inflation are important?

- A smoking gun of a period of inflation in the early universe
- The amplitude of the inflationary gravity waves probes the *energy scale of inflation*

$$V^{1/4} = 1.06 \times 10^{16} \text{ GeV} \left( \frac{r}{0.01} \right)^{1/4}$$

GUT SCALE

- *a detection would provide a firm observational link to physics of the early universe, characterized by energies never achievable in labs.*
- inflationary gravity waves generate a *unique* imprint into the CMB *polarization pattern*

"Large field" models can produce a high level of gravity waves  
( $r > 0.01$ )

"Small field" models produce a low level of gravity waves  
( $r < 0.01$ )

Take the previous formula

$$N_{CMB} \simeq -8\pi G \int_{\phi_{CMB}}^{\phi_f} \frac{V}{V_{,\phi}} d\phi \sim (8\pi G)^{1/2} \int_{\phi_{CMB}}^{\phi_f} \frac{d\phi}{\epsilon^{1/2}} \sim \frac{1}{M_{pl}} \frac{1}{\epsilon^{1/2}} \int_{\phi_{CMB}}^{\phi_f} d\phi$$

Then

$$\epsilon^{1/2} \sim \left( \frac{\Delta\phi}{M_{Pl}} \right) \frac{1}{N_{CMB}}$$

but remember the tensor-to-scalar ratio  $r \sim \epsilon$

So the bigger is the field excursion during inflation the bigger is the amplitude of the gravity waves

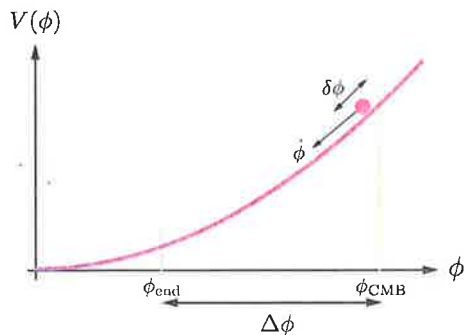
## Before seeing why is that.....

Let us first compute the number of e-foldings between a generic time during inflation and the end of inflation *in terms of the scalar field*

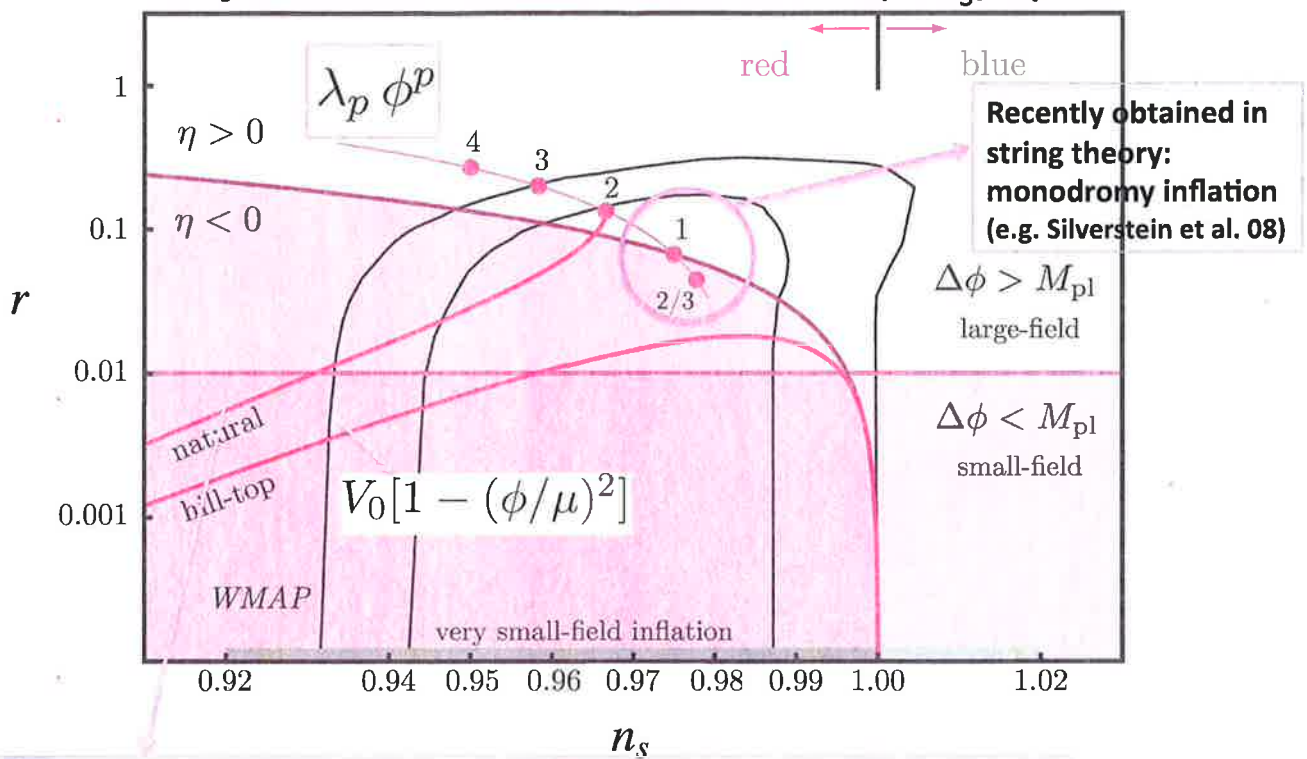
$$N = \int_t^{t_f} H dt \simeq H \int_\phi^{\phi_f} \frac{d\phi}{\dot{\phi}} \simeq -3H^2 \int_\phi^{\phi_f} \frac{d\phi}{V_{,\phi}} \simeq -8\pi G \int_\phi^{\phi_f} \frac{V}{V_{,\phi}} d\phi$$

For example: the scales of wavenumber  $k$  relevant for CMB cross the horizon during inflation  $N_k$  e-foldings before the end of inflation given by

$$N_k = \int_{t_k}^{t_f} H dt \simeq -8\pi G \int_{\phi(t(k))}^{\phi_f} \frac{V}{V_{,\phi}} d\phi \quad N_k \text{ must be of the order of } 60$$



## “Trajectories” of models in the (r-n<sub>s</sub>) space



Natural inflation  
shift symmetry slightly broken  $V_0[1 - \cos(\phi/\mu)]$