## 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*

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

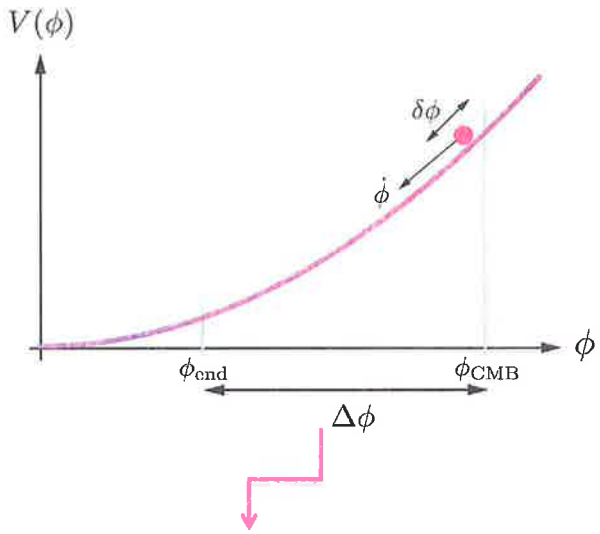
GUT SCALE

- *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*

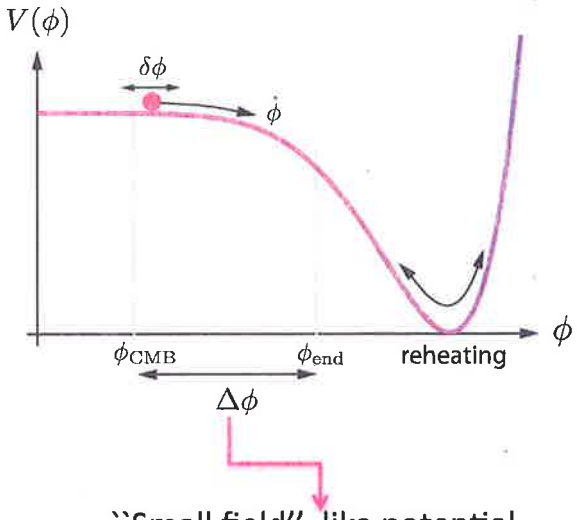
# Classifying inflationary models

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

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




``Large field'' like potential




``Small field'' like potential
predict ε very very small

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

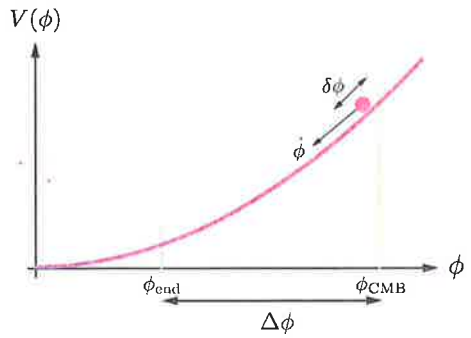
Let us first compute the number of e-foldings between a generic time during inflation and the end of inflation *in terms of the scalar field*

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

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

$$N_k = \int_{t_k}^{t_f} H dt \simeq -8\pi G \int_{\phi(t(k))}^{\phi_f} \frac{V}{V_{,\phi}} d\phi$$

$N_k$ must be of the order of 60



"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

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

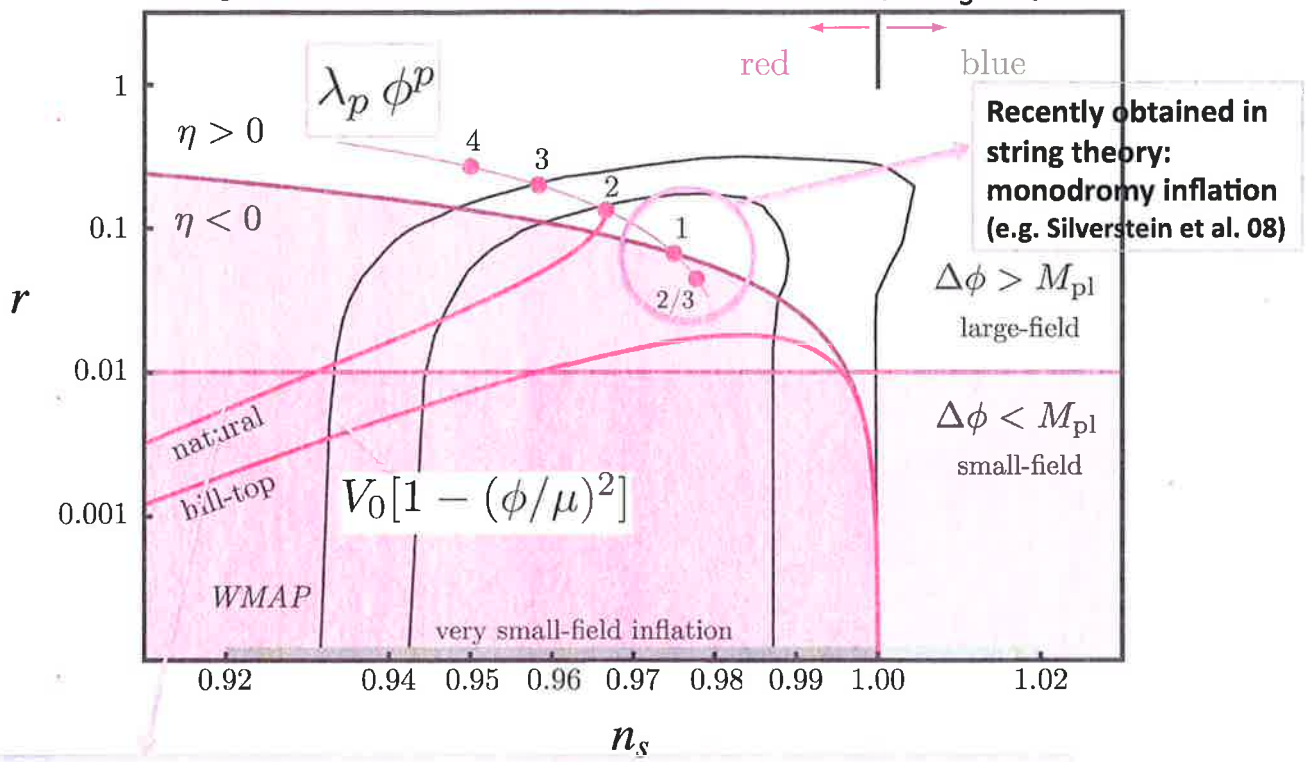
Then** $$\epsilon^{1/2} \sim \left(\frac{\Delta\phi}{M_{Pl}}\right) \frac{1}{N_{CMB}}$$

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

**: Per arrivare a questo risultato si puo` anche partire dalla formula sulla escursione del campo scalare che e` stata ricavata alla fine delle note del file chiamato "Blocco2.pdf".

# ``Trajectories'' of models in the (r-$n_s$) space




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