

Ticket №7

1. Cosmic rays of ultrahigh energies . Problem of their origin

Cosmic rays – are particles and atomic nuclei, which have high energies in space.

Cosmic rays can consist:

- e^+/e^- ;
- Protons;
- Photons;
- Iron nuclei and etc.;

The value of cosmic rays energies has upper limit – Greisen-Zatsepin-Kuzmin limit.

Greisen-Zatsepin-Kuzmin limit – is theoretical upper limit for cosmic rays energies from distant sources: $E = 5 \times 10^{19} \text{ eV}$.

$$\gamma_{CMB} + p \rightarrow \Delta^+ \rightarrow \begin{cases} N + \pi \\ e^+ \text{ or } e^- + p \end{cases}$$

But, ultra high energy cosmic rays (UHECR) were detected by AGASA: their energy was above than this limit

- UHCER is anisotropic;

Possible UHCER origin:

- Pulsars;
- Accretion disk;
- Cosmic string;
- Decay or annihilation of hypothetical supermassive relic particles;
- UHE-neutrinos;

2. Inflation

$$\begin{cases} \frac{\ddot{a}}{a} = -\frac{4\pi G}{3} \left(\varepsilon + \frac{3p}{c^2} \right) + \frac{\Lambda c^2}{3} \\ \left(\frac{\dot{a}}{a} \right)^2 - \frac{8\pi G \varepsilon}{3} = -\frac{K c^2}{a^2} + \frac{2\Lambda c^2}{3} \end{cases}$$

The inflation model can explain why the Universe is expanding.

This model bases on follow condition:

$$p < -\frac{\varepsilon}{3};$$

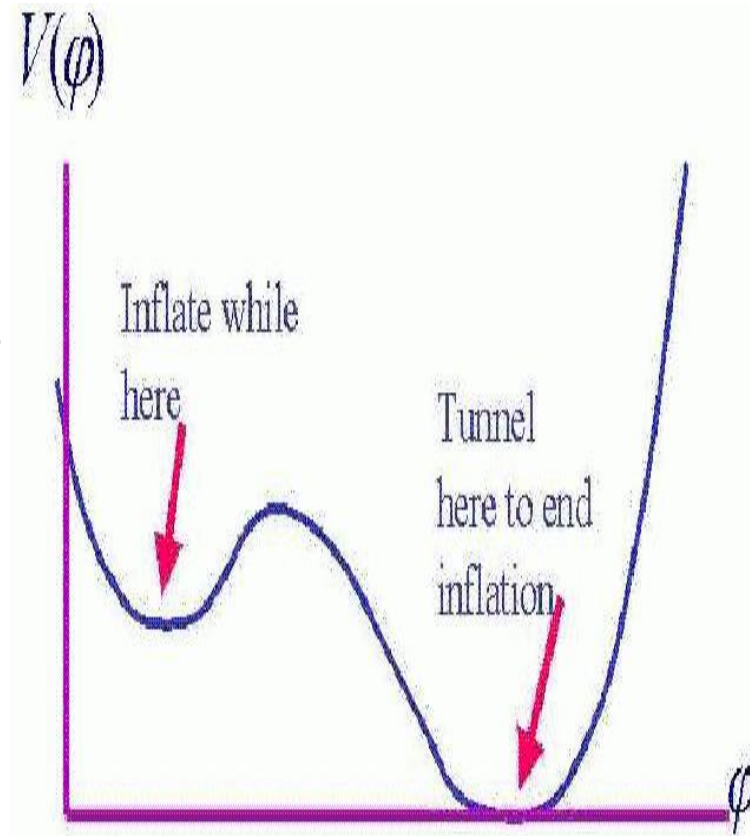
This condition provide a positive acceleration value from Friedman's equation:

$$\begin{aligned} \left(\frac{\dot{a}}{a} \right)^2 &= -\frac{4\pi G}{3c^2} (\varepsilon + 3p); \\ a &\propto e^{\left\{ \int H dt \right\}}; \end{aligned}$$

This theory was introduced by Guth and resolved problems:

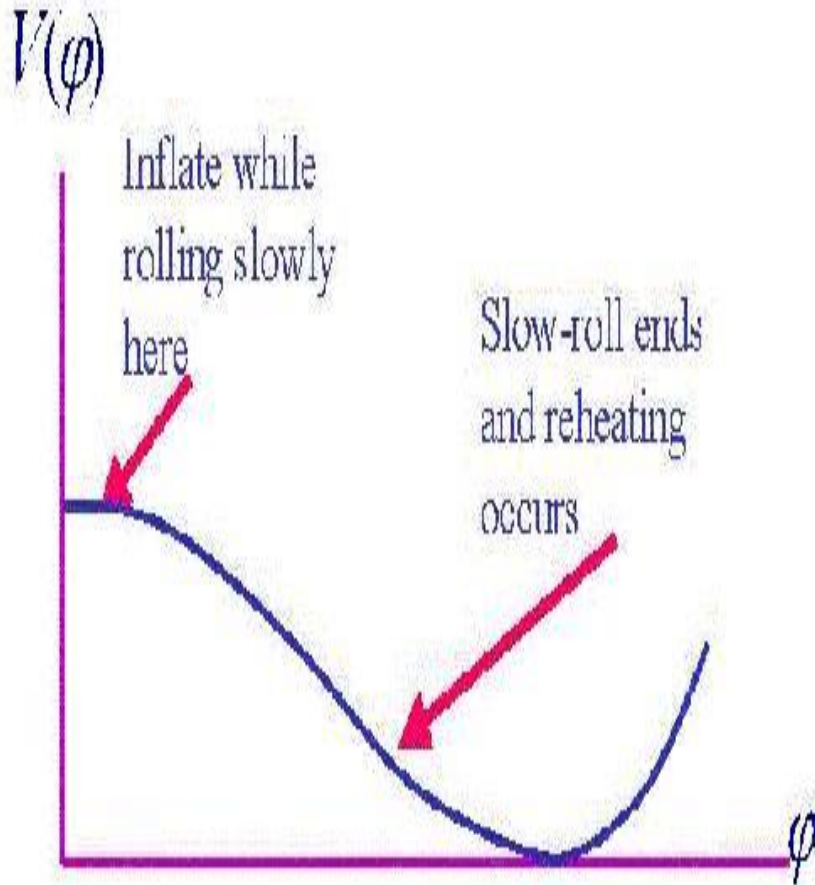
- Monopoles overproduction: $n \sim \frac{1}{a^3} \sim e^{-Ht} \rightarrow 0$;
- Horizon and flatness problems;

$$L = \frac{1}{2} \partial_\mu \varphi \partial^\mu \varphi - V(\varphi);$$

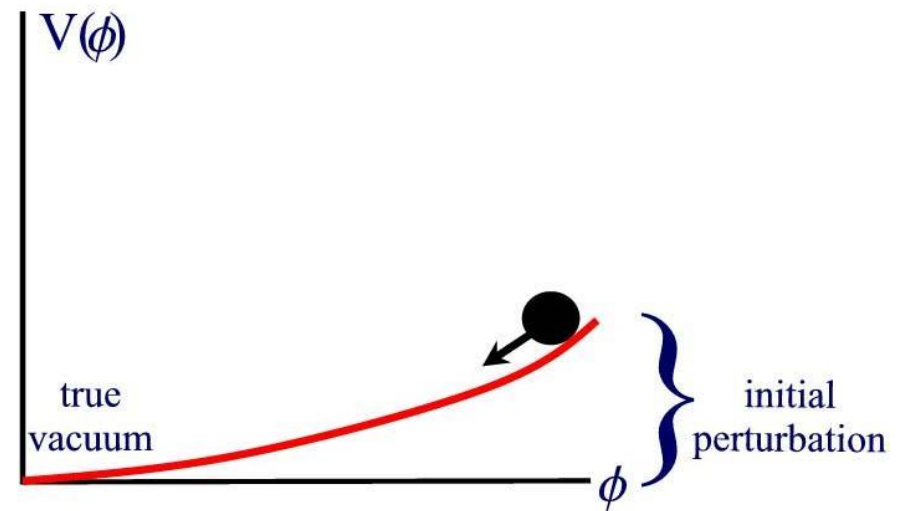


- Too large inhomogeneities;
- Problem of before-inflation conditions;

Slow rolling down



- The transition from the inflationary stage is due to the slow roll of the effective potential to the true vacuum;
- Effective potential must be too flat;



Chaotic inflation