Higgs boson and the cosmos

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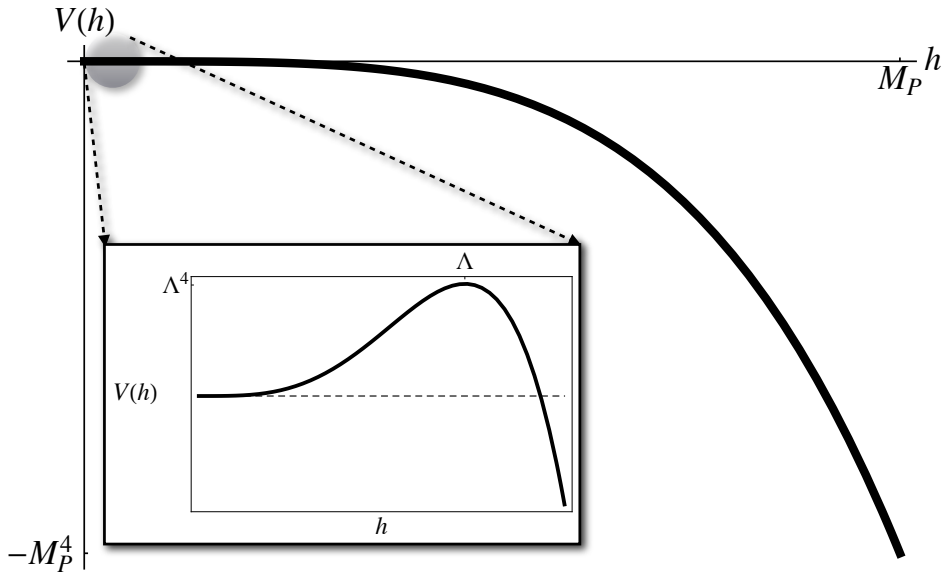
Assuming no new physics up to the Planck scale, this is the Higgs potential for large values of the field:



Two cosmological problems:

- Huge fine tuning to put the Higgs field in the false vacuum.
- Fluctuations of the Higgs field are proportional to the Hubble scale H during inflation. If $H > \Lambda$, it is likely to end up in the true vacuum.

Minimal Beyond SM setup:

Introduce the renormalizable coupling

$$\frac{1}{4}\lambda_{h\phi}h^2\phi^2 \longrightarrow m_h^2 = \lambda_{h\phi}\phi_0^2/2$$

For $\phi_0 >> M_{\rm Pl}$ it induces an effective mass term for h above the Hubble scale.

Result:

This makes the Higgs potential convex during inflation and thus h is pushed to the origin.

The coupling inflaton-Higgs is well motivated

The inflaton must transfer its energy density into SM particles!
This process is called reheating:

Reheating requires a coupling between inflaton and SM particles
It turns out that the coupling $h^2\phi^2$ is required by renormalizability in every realistic reheating model.

Thank you