Inflation and reheating in Starobinsky model with conformal higgs field

Gorbunov D.S., Tokareva A.A.

MSU, INR

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Starobinsky model

Action in a Jordan frame

$$S = -\frac{M_P^2}{2}\int\sqrt{-g}\,d^4x\left(R-\frac{R^2}{6\,\mu^2}\right)+S_{matter}$$

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Equations of motion consist 4th derivatives of $g_{\mu\nu}$

A. A. Starobinsky, Phys. Lett. B **91** (1980) 99

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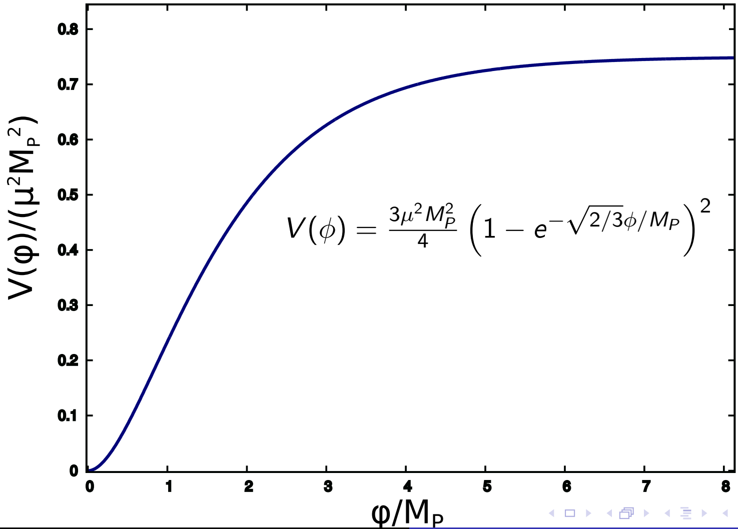
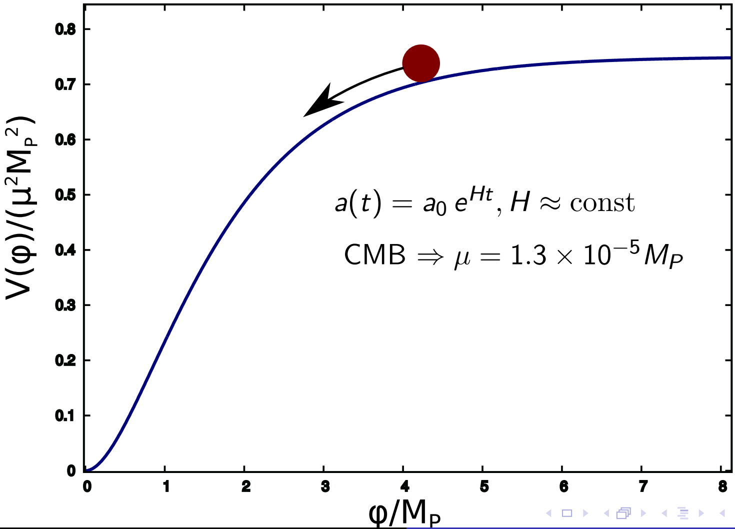
$$V(\phi) = \frac{3\mu^2 M_P^2}{4} \left(1 - e^{-\sqrt{2/3}\phi/M_P} \right)^2$$

The scalaron's potential



Inflation in a slow roll regime



Reheating in Starobinsky model

Decay to Higgs bosons:

$$g_{\mu\nu} \to e^{\sqrt{2/3}\phi/M_P} g_{\mu\nu}, \;\; h \to e^{-\sqrt{1/6}\phi/M_P} h,$$

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Width:

$$\Gamma_{\phi \to h\,h} = \frac{\mu^3}{192\pi M_P^2} \to T_{reh} = 3.1 \times 10^9 \mathrm{GeV}$$

Conformal Higgs field

$$S_H = \int d^4x\sqrt{-g}\left(\frac{1}{6}R\,(H^\dagger H) + |D^\mu H|^2 - \frac{\lambda}{4}(H^\dagger H - v^2)^2\right)$$

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What is the reheating mechanizm?

The gauge anomaly

$$L = -\frac{1}{4} F^a_{\mu\nu} F^{\mu\nu}_a ,$$

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SU(3), gluons:

$$L_{int} = \frac{7\alpha_s}{4\pi\sqrt{6}M_p} \phi \partial_\mu A^a_\nu \partial_\mu A^a_\nu + o(...)$$

$$\Gamma_{\phi\to 2\ \mathrm{gluons}} = \frac{49\,\alpha_s^2}{96\,\pi^3} \frac{\mu^3}{M_p^2} \to T_{reh} = 1.3\times 10^8 \mathrm{GeV}$$

Predictions for n_s, r: usual higgs vs conformal

$$\langle\phi^2\rangle = \int \frac{dk}{k} P(k),\ \ r = \sqrt{\frac{P_T}{P_s}},\ \ P_s \sim k^{n_s - 1}$$

$\mathbf{R^2}$ with $\mathbf{R\,H^+H}$: $\mathbf{n_s = 0.962},\ \ \mathbf{r = 0.0041}$

R^2-inflation: $n_s = 0.965,\ \ r = 0.0036$ (F. Bezrukov and D. Gorbunov, arXiv:1111.4397 [hep-ph])

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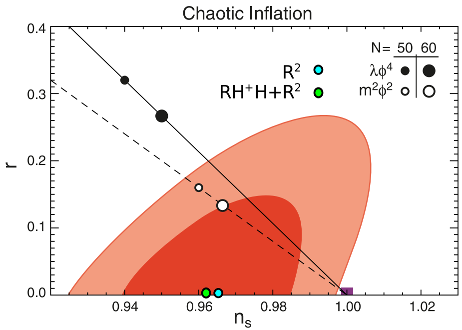
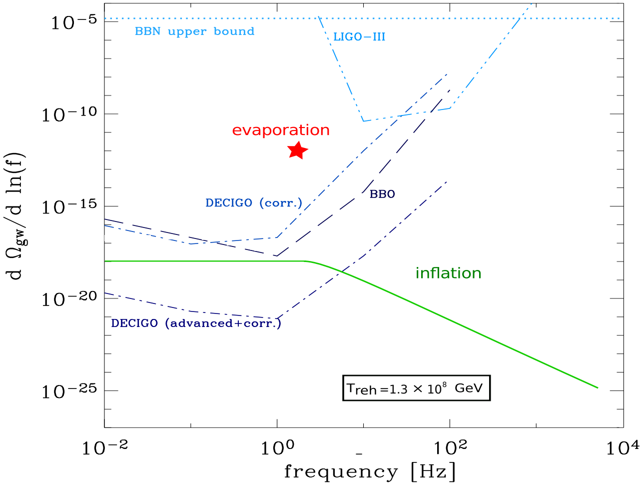


The gravity wave spectrum



K. Jedamzik, M. Lemoine and J. Martin, JCAP **1004** (2010) 021 [arXiv:1002.3278 [astro-ph.CO]]

Effective potential

For large fields ($\gg$ 246 GeV):

$$V = \frac{\lambda(h)}{4} h^4 - \frac{1}{12} R\, h^2$$

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$\lambda(h)$ is defined by RG equations on SM couplings.
If $m_h \lesssim 129$ GeV $\lambda(h)$ reaches negative values

(F. Bezrukov, M. Y. .Kalmykov, B. A. Kniehl and M. Shaposhnikov, arXiv:1205.2893 [hep-ph])

$\rightarrow$ **metastability**

Our vacuum is false

Possible dangers for Higgs

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- Higgs fluctuations at the inflationary stage

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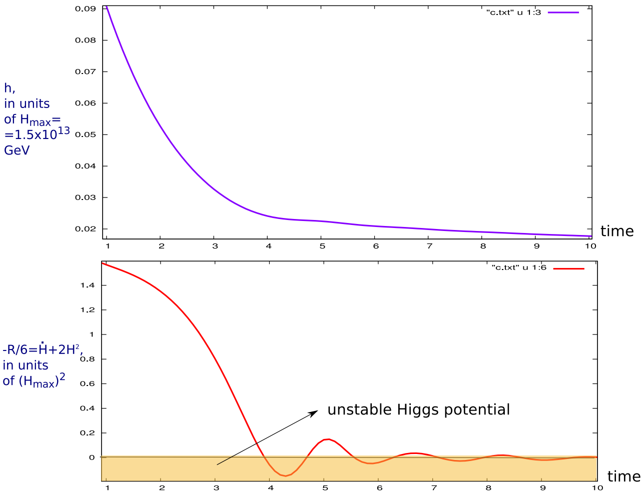
- After inflation If we set $h(0) = \sqrt{\langle h^2 \rangle}_{max} \simeq 0.14H$
  $m_h = 115.5$ GeV (CMS, ATLAS limit, the most bad case)
  and run the classical evolution of the Higgs field

Higgs field dinamics after inflation



Conclusions

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- No new free parameters
- Valid n_s, r
- Gravity wave signal from structure evaporation at the moment of reheating can be detected by DECIGO
- Model is consistent for 125 GeV Higgs as well as for all non-closed mass range

DECIGO

Let's wait!

Thanks for your attention!