Sizeable tensor modes and the gravitino problem

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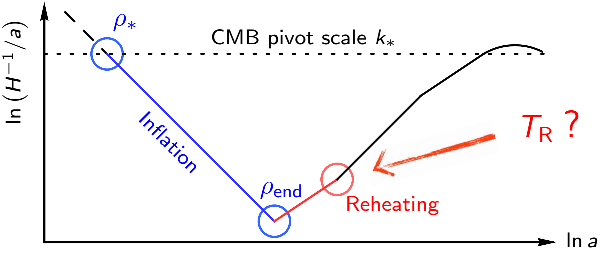
Based on Valerie Domcke, JH, work in progress
and JH 1310.6352

Introduction and Overview

Measurement of tensor-to-scalar ratio $r \Rightarrow \rho_*$



Important for:

- Leptogenesis
- Thermal relics
  (gravitino problem)

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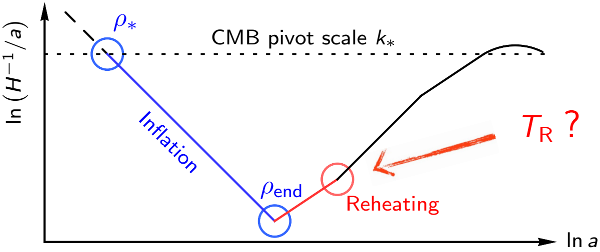

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Constrain ρ_{end} from ρ_*:

- N_* (e-folds) roughly known
- Slow-roll: V', V'' constrained
- Constraints from Planck

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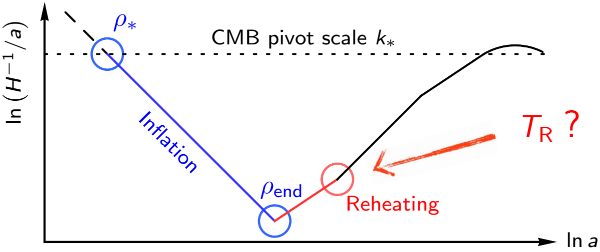

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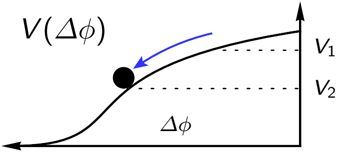
Constrain T_{R} from ρ_{end}:
- Transition time-scale
- Decay of massive inflaton
- $\Gamma_\phi \sim \lambda^2 m_\phi$, dim-5: $\lambda \sim \frac{m_\phi}{M_{\text{Pl}}}$

A lower bound on V_{end} for slow-roll inflation



Consider ratio V_1/V_2:

$$\frac{V_1}{V_2} = \sqrt{\frac{\epsilon_2}{\epsilon_1}} \times \exp\left(\int_{\epsilon_2}^{\epsilon_1} \frac{\eta\, \mathrm{d}\epsilon}{2\epsilon\,(\eta - 2\epsilon)}\right)$$

Slow-roll parameters:

$$\epsilon = \frac{1}{2}\left(V'/V\right)^2,\ \eta = V''/V$$

Three limiting cases:

- $\eta \gg \epsilon$: $\frac{V_1}{V_2} \simeq 1$ (quick end)
- $\epsilon \gg \eta$: $\frac{V_1}{V_2} \simeq \sqrt{\frac{\epsilon_2}{\epsilon_1}}$ (linear potential)
- $2\epsilon = \eta$: $\frac{V_1}{V_2} = \mathrm{e}^{\sqrt{2\epsilon}\,(\Delta\phi_1 - \Delta\phi_2)}$ (exponential potential)

  $\rightarrow$ Largest potential drop

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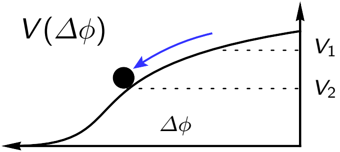

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A lower bound on $V_{\rm end}$ for slow-roll inflation

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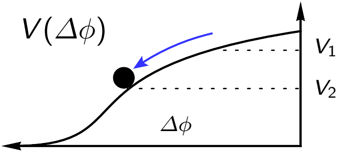

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Most conservative bound!

Bound on V_{end} in a generic framework

Assumption: V has no operator beyond dim-4

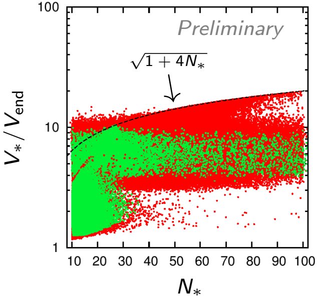
$$V(\phi) = \sum_{n=0}^{4} a_n \phi^n$$

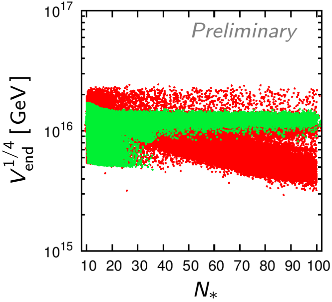
Constraint from the CMB [Planck '13]

$$A_s = \left(2.196^{+0.051}_{-0.060}\right) \times 10^{-9}\,, \quad n_s = 0.9570 \pm 0.0075\,, \quad r < 0.23$$

$$\alpha_s = \mathrm{d}n_s/\mathrm{d}\ln k = -0.022^{+0.011}_{-0.010}\,, \quad \kappa_s = \mathrm{d}^2 n_s/\mathrm{d}\ln k^2 = 0.022^{+0.016}_{-0.013}$$

Bound on $V_{\rm end}$ in a generic framework





All points

Allowed by Planck data

We use $V_{\rm end} = V(\epsilon = \epsilon_{\rm end})\,,\ \epsilon_{\rm end} = 1$

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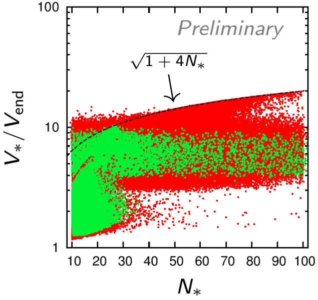

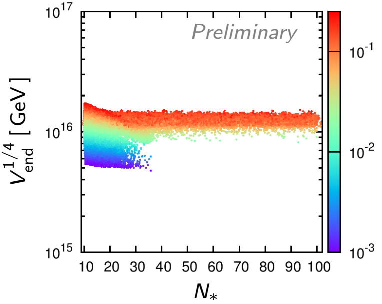

All points

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We use $V_{\text{end}} = V(\epsilon = \epsilon_{\text{end}})$, $\epsilon_{\text{end}} = 1$

Implications for the reheating temperatur

$$\ddot{\phi} + 3H\dot{\phi} + V'(\phi) + \Gamma\dot{\phi} = 0$$

$$V(\phi) = \frac{1}{2}m_\phi^2(\phi + c)^2 \quad \text{for } \phi < \phi_{end}$$

$$m_\phi^2 = \epsilon_{end} V(\phi_{end})/M_{\mathrm{Pl}}^2$$

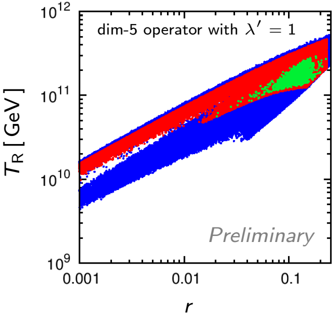
$$T_{\mathrm{R}} \sim \sqrt{\Gamma_\phi M_{\mathrm{Pl}}}$$

$$\Gamma_\phi \sim \lambda_i^2 m_\phi \,, \quad \lambda_i = \lambda_i' \left(\frac{m_\phi}{M_{\mathrm{Pl}}}\right)^{i-4} \,, \quad i = 4, 5, 6 \,, \quad \lambda_i' = \mathcal{O}(1)$$

Implications for the reheating temperatur

- Using consistency constraint:

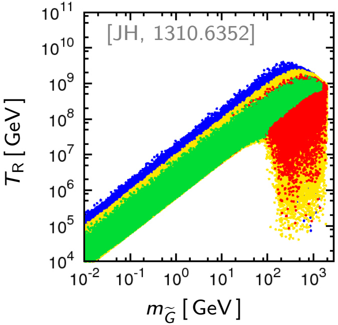
$$N_* \simeq 66 + \frac{1}{4}\log\frac{V_*^2}{V_{\rm end}} + \frac{1}{12}\log\frac{\rho_{\rm R}}{V_{\rm end}}$$



- All points (blue)
- Allowed by Planck data (red)
- $N_* \in \{N_*(V_*, V_{\rm end}, \rho_{\rm R}) \pm 3\}$ (green)

What does that mean for SUSY?

- Highest reheating temperatures in a gravitino DM scenario



No constraints | Flavor/precision bounds, CCB bounds

SUSY searches | BBN bounds

Conclusions

- Derived robust limits on V_{end}
- Large potential drop only in an exponential potential
  otherwise $V_*/V_{\text{end}} \lesssim 10$
- Consistent points with $T_{\text{R}} \simeq 10^{11}\,\text{GeV}$ for dim-5 operator
- Sizable tensor-to-scalar ratio can have implications for SUSY
  $\rightarrow$ Gravitino Problem
- Gravitino DM: Points up to $T_{\text{R}} \simeq 10^{9}\,\text{GeV}$ only

Thank you for your attention!