Lower bound on the gravitino mass in R breaking new inflation model

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R symmetry and its breaking

Unique symmetry which can controll a constant term in the superpotential

$$W = W_0 + \cdots$$

$$V = e^K \left(|W_i + K_i W|^2 - 3|W|^2 \right)$$

SUSY R

Helpful for low energy SUSY

Necessity of Discrete R symmetry

Dine, Festuccia, Komargodski (2010)

For continuous R symmetry,

$$|W| < |f_R \times F_{\rm SUSY}|$$

$$\begin{cases} f_R & \text{decay constant of R} \\ F_{\rm SUSY} & \text{decay constant of SUSY} \end{cases}$$

$$|F_{\rm SUSY}| \sim |W| \sim m_{3/2} \to |f_R| \sim 1$$

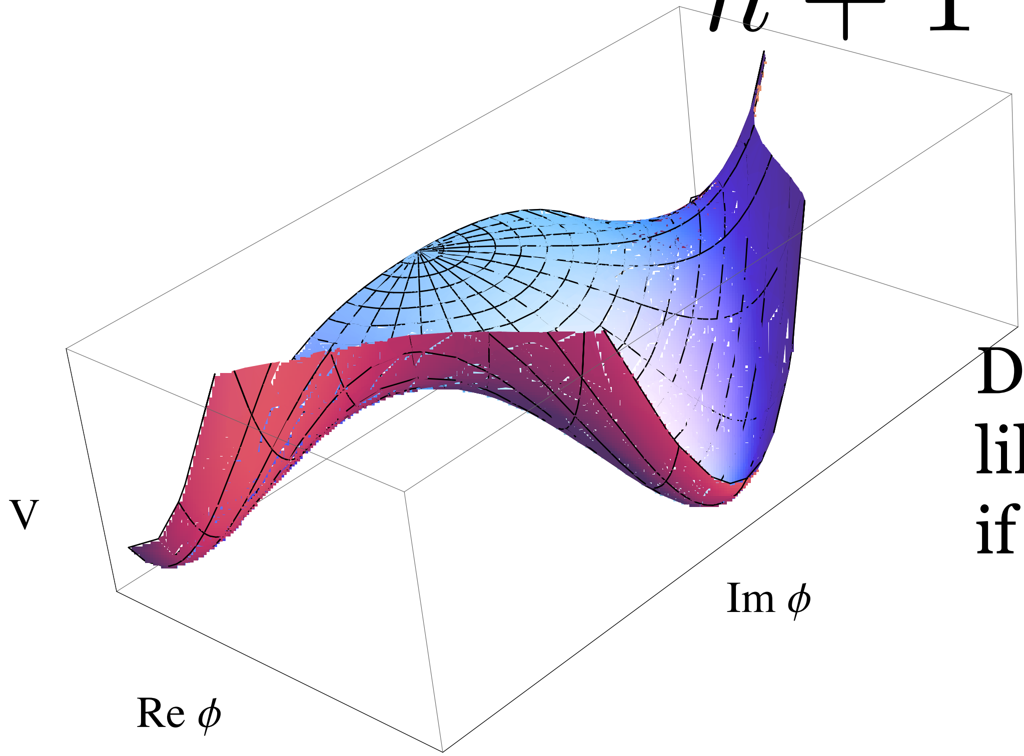
Non-zero F term, Planck order vev → Polonyi problem !

A simple R symmetry breaking model

Kumekawa, Moroi, Yanagida (1994)

$$W = v^2 \phi + \frac{g}{n+1} \phi^{n+1}$$

	W	ϕ
Z_{2nR}	2	2



Due to its small scale,
likely to induce the last inflation,
if it slow rolls

Inflation scale and the gravitino mass

Planck (2013)

Planck + WP + BAO

$$n_s = 0.9643 \pm 0.012 \; (95\% C.L.)$$

$$\mathcal{P}_\zeta \simeq 2.2 \times 10^{-9}$$

$$k_* = 0.002 \text{ Mpc}^{-1}$$

We can find a bound on the gravitino mass

How to set the bound

$$W = v^2\phi + \frac{g}{n+1}\phi^{n+1} + \cdots$$

$$K = \phi\phi^\dagger + \frac{1}{4}k(\phi\phi^\dagger)^2 + \cdots$$

3 parameters $v^2, \ g, \ k$

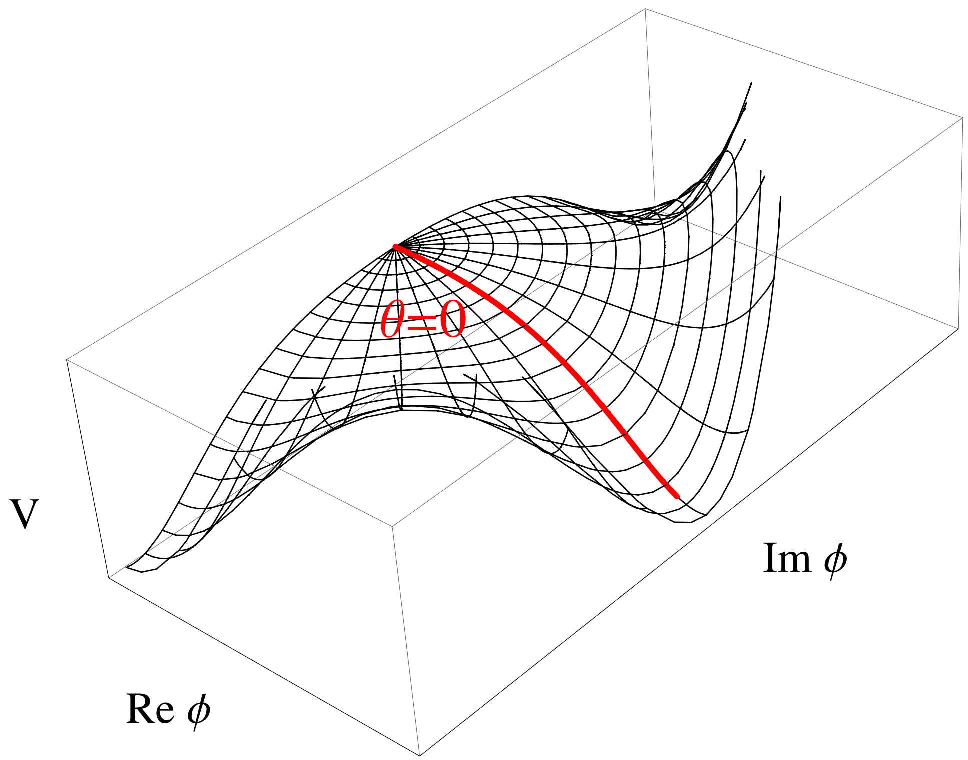
2 observables $n_s, \mathcal{P}_\zeta$

Unitarity bound on couplings

Inflaton trajectory

$$V(\varphi,\theta) = v^4 - \frac{k}{2}v^4\varphi^2 - \frac{g}{2^{n/2-1}}v^2\varphi^n \cos(n\theta) + \cdots .$$

$$\phi = \frac{1}{\sqrt{2}}\varphi \times e^{i\theta}$$



Let us assume $\theta = 0$
For the time being

Calculations

$$\epsilon = \frac{1}{2}(V'/V)^2$$

$$\eta = V''/V$$

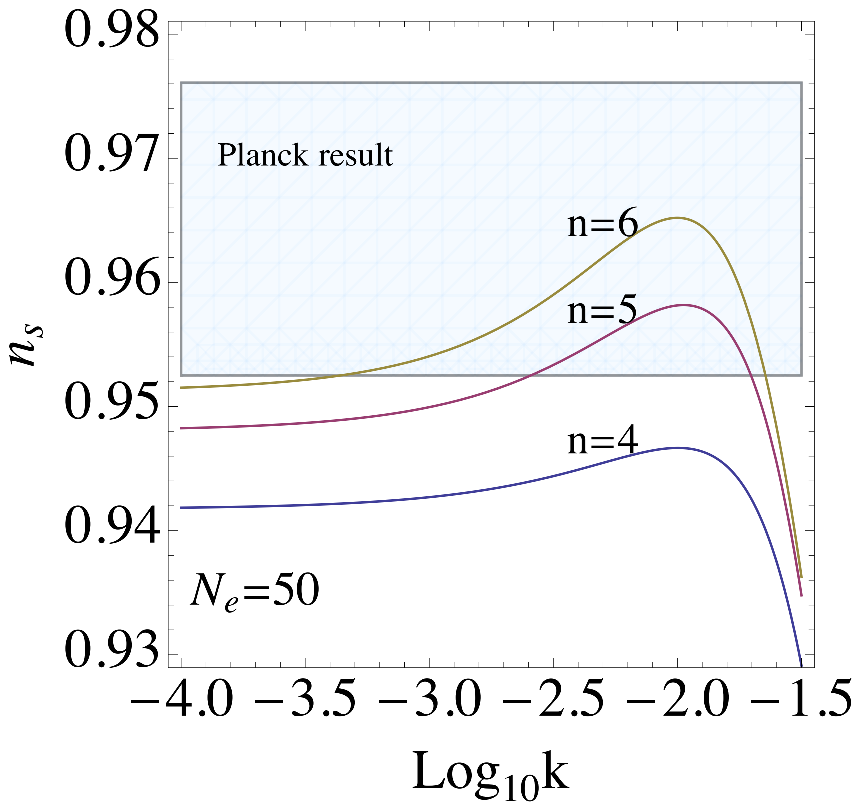
$$\mathcal{P}_\zeta = \frac{1}{24\pi^2}\frac{V}{\epsilon}$$

$$n_s = 1 - 6\epsilon + 2\eta$$

Spectral index

$$K = \phi\phi^\dagger + \frac{1}{4}k(\phi\phi^\dagger)^2 + \cdots$$

$$W = v^2\phi + \frac{g}{n+1}\phi^{n+1} + \cdots$$



Depend only on k

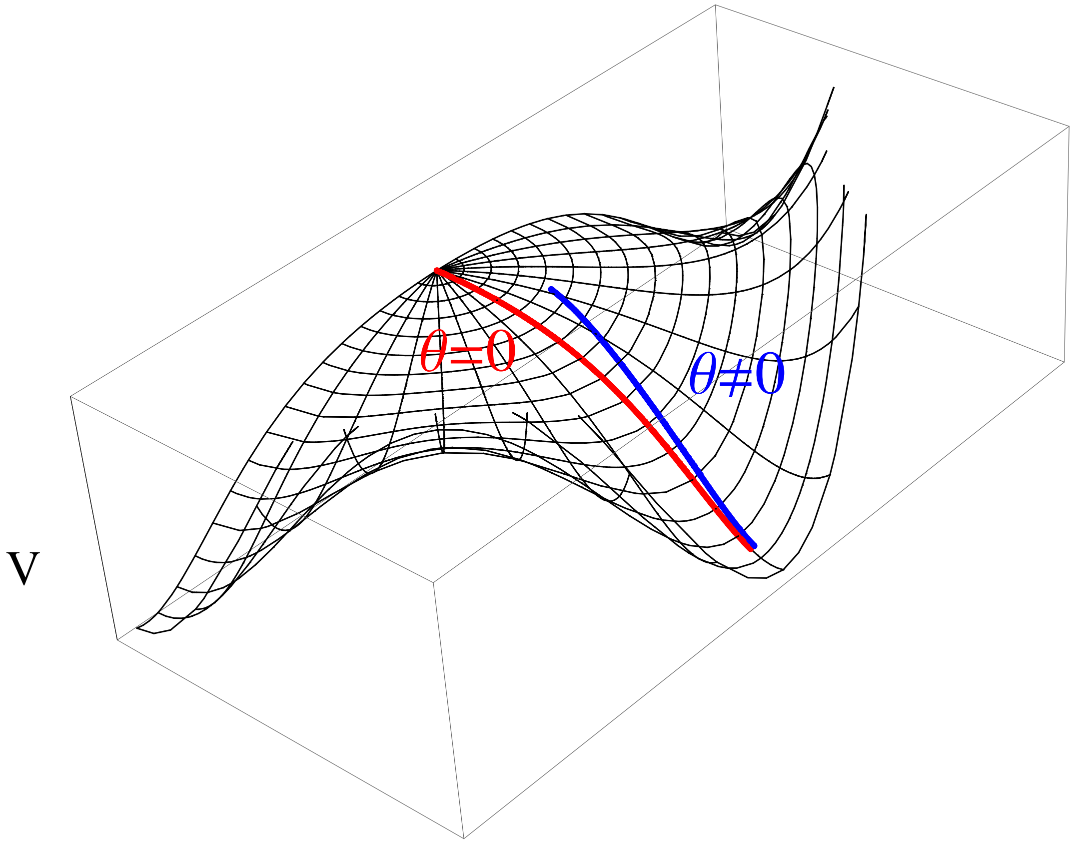
(g, v hidden in N_e)

Large k -> eta problem

Small k -> large field value
-> large mass

$$k \sim 10^{-2}$$

Non-zero angular direction



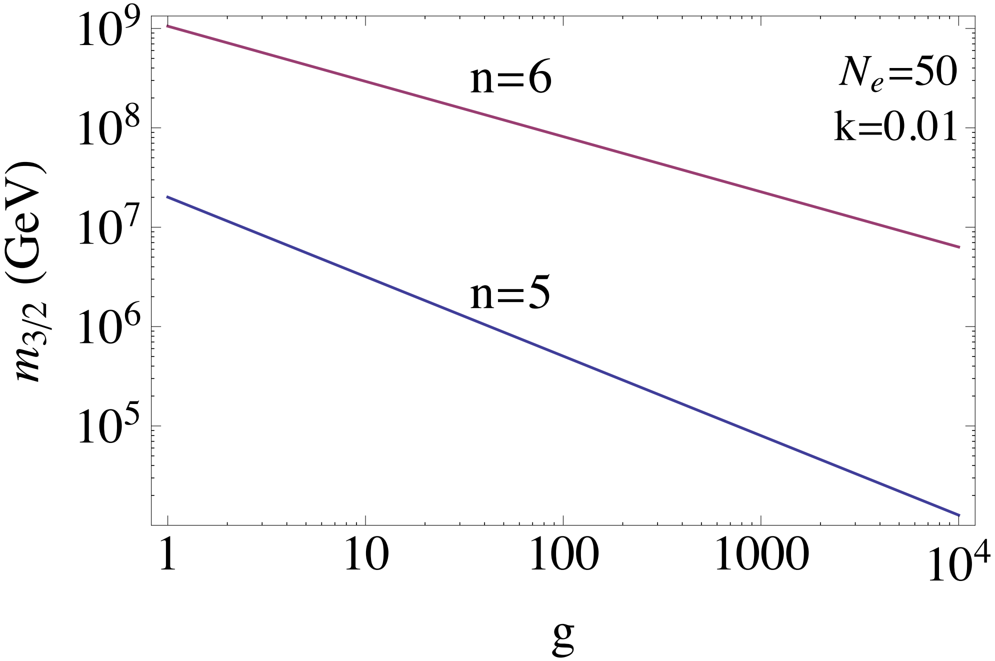
Large field value → large mass → more red-tilted

$$K = \phi\phi^\dagger + \frac{1}{4}k(\phi\phi^\dagger)^2 + \cdots$$

$$W = v^2\phi + \frac{g}{n+1}\phi^{n+1} + \cdots$$

Curvature perturbation

$$v^2 = \mathcal{P}_\zeta^{\frac{n-2}{2(n-3)}} g^{-1/(n+3)} \times \cdots$$



Small g, large n → flat potential → large vev

Unitarity bound on g

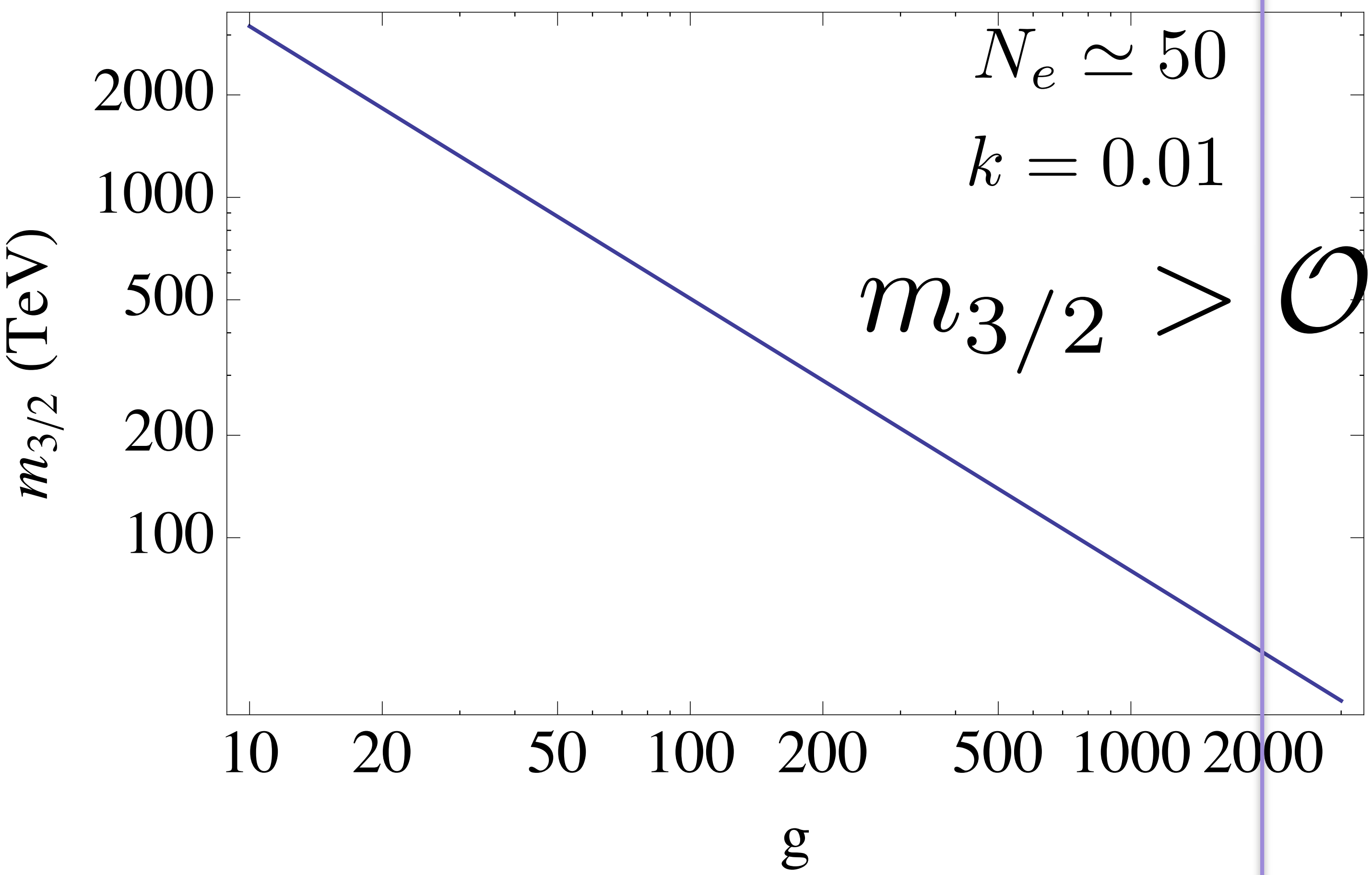
n=5 $$W = \frac{g}{6}\phi^6$$ Assume cut off at the Planck scale

$$|\delta K| \sim \frac{5!}{(16\pi^2)^4} g^2 \phi\phi^\dagger < \phi\phi^\dagger$$

(equivalent to Born unitarity up to Planck scale)

$$g < (16\pi^2)^2/\sqrt{5!} \simeq 2000$$

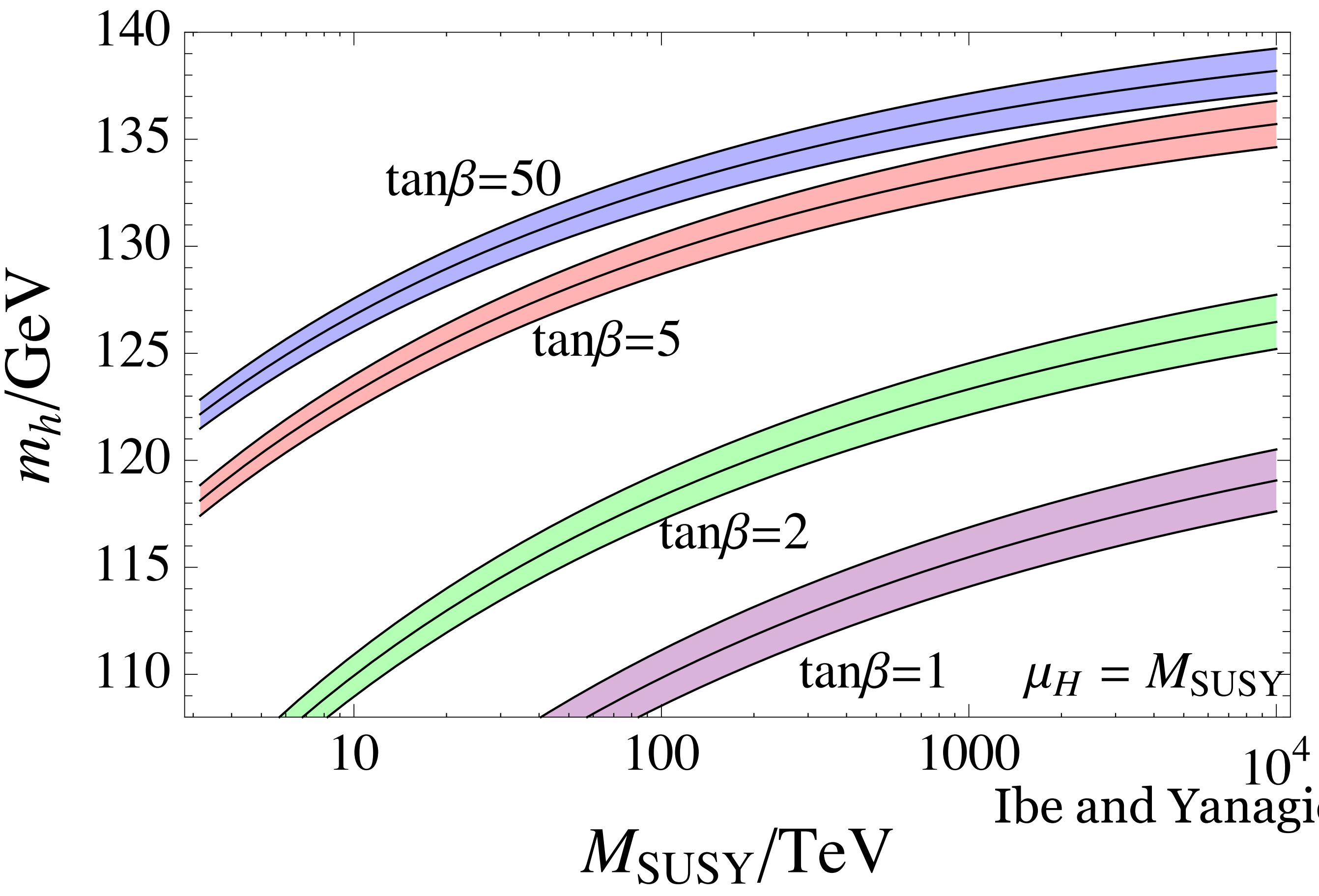
Lower bound on the gravitino mass



$$m_{3/2} > \mathcal{O}(100)\,\mathrm{TeV}$$

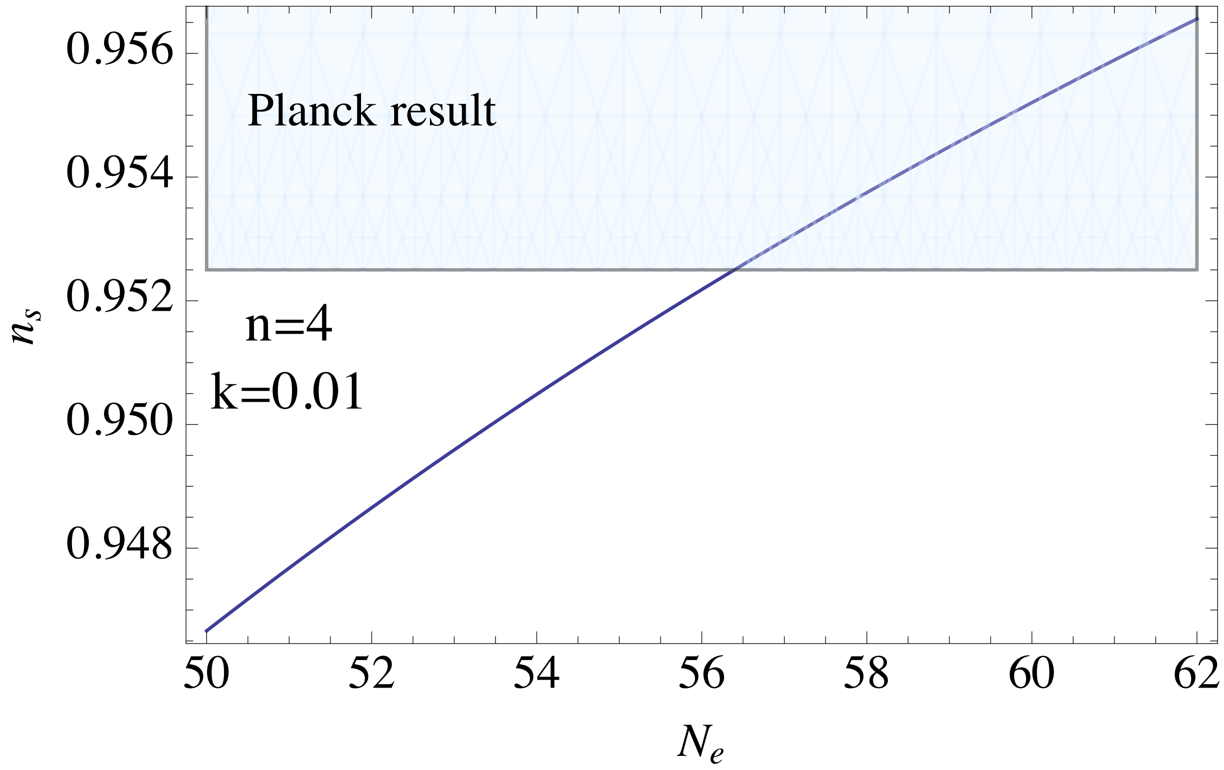
125 GeV Higgs

Quantum correction by top quark



Ibe and Yanagida (2012)

Is n=4 possible?



Large e-folding → small field value → small mass → blue-spectrum

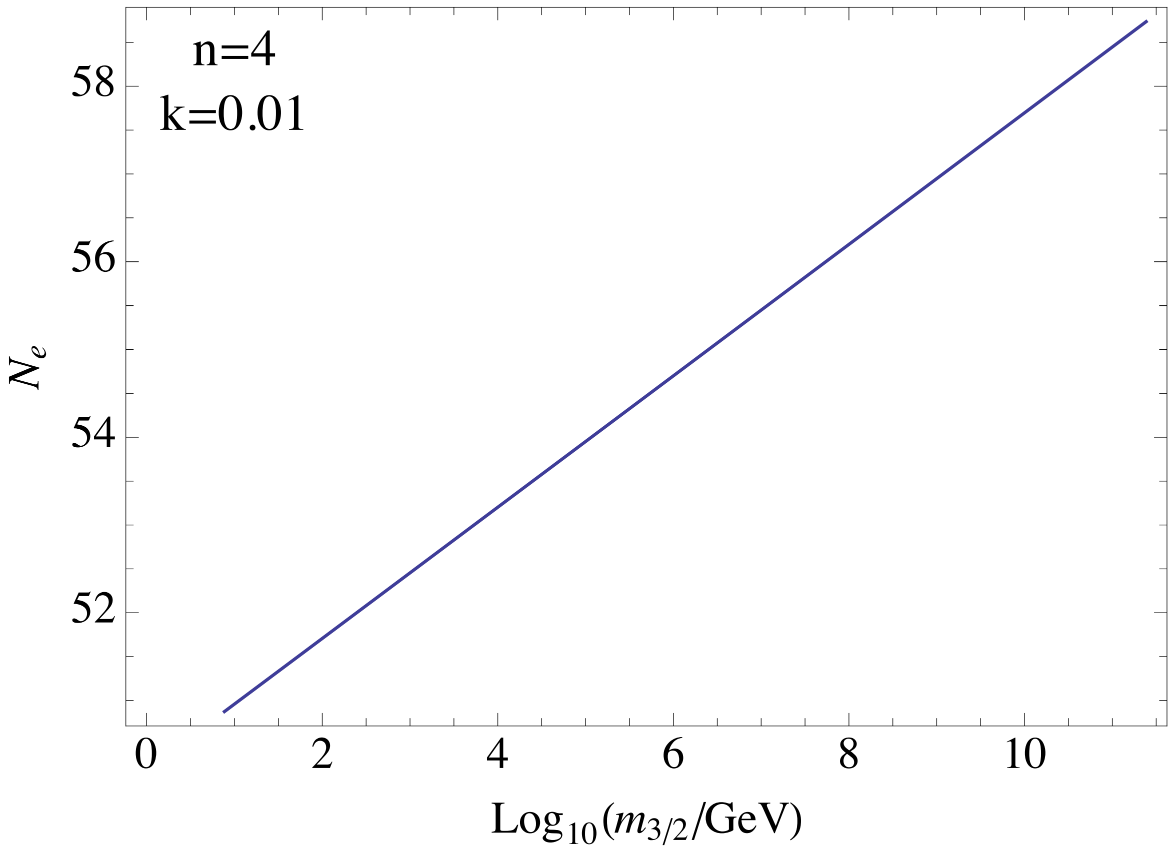
$$N_e \geq 56$$

$$K = \phi\phi^\dagger + \frac{1}{4}k(\phi\phi^\dagger)^2 + \cdots$$

$$W = v^2\phi + \frac{g}{n+1}\phi^{n+1} + \cdots$$

Is n=4 possible?

$$N_e \leq 52 + \ln\left(\frac{v}{10^{12}\mathrm{GeV}}\right)$$ (equality for instantaneous reheating)



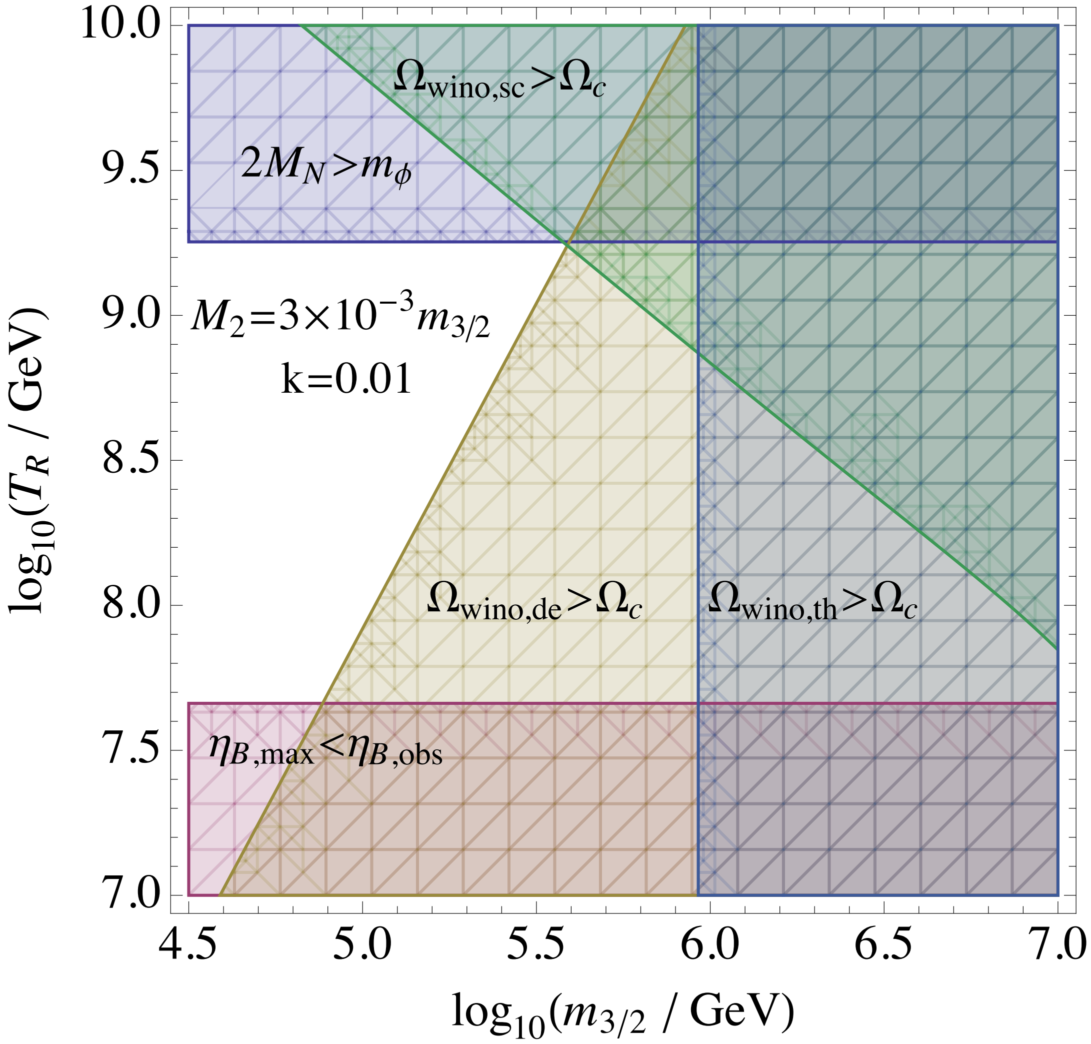
Dark matter, Baryon assymmetry

Asuume

$$W = \frac{y}{2l}\phi^l N N$$

and

Anomaly mediated gaugino mass



Dark matter, Baryon assymmetry

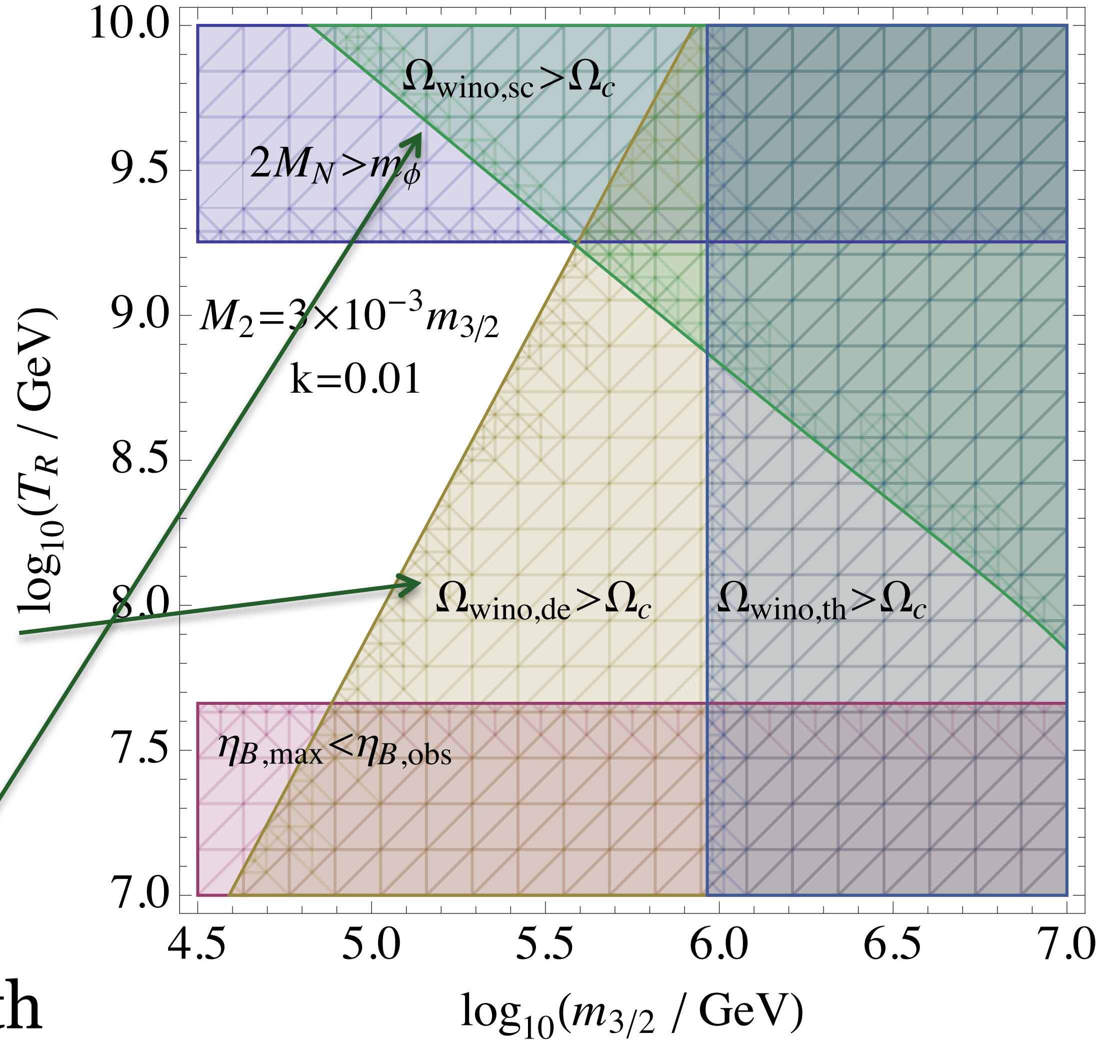
Asuume

$$W = \frac{y}{2l}\phi^l N N$$

and

Anomaly mediated gaugino mass

Inflaton decay into gravitino



Gravitino from thermal bath

$$K = \phi\phi^\dagger + \frac{1}{4}k(\phi\phi^\dagger)^2 + \cdots$$

$$W = v^2\phi + \frac{g}{n+1}\phi^{n+1} + \cdots$$

Summary

- Simple R symmetry breaking model is a natural candidate for the inflation model
- Unitarity limit put a lower bound on the gravitino mass
- The bound is consistent with the observed higgs mass

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