WMAP constraints on SUGRA F-term inflation and Leptogenesis

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Leiden, The Netherlands

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RJ and M. Postma, JHEP 0505:071, 2005 (hep-ph/0503146)

RJ and M. Postma, hep-ph/0507162

Outline

- Standard hybrid inflation
    - SUSY GUTs
- CMB constraints
- Leptogenesis
- Conclusions

Standard hybrid inflation

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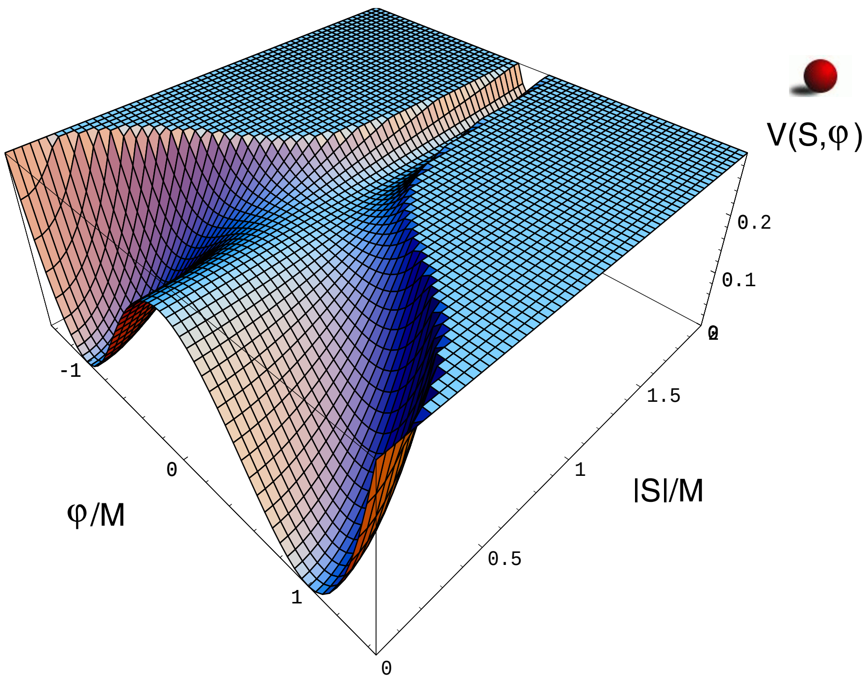

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Dvali *et al.* 94

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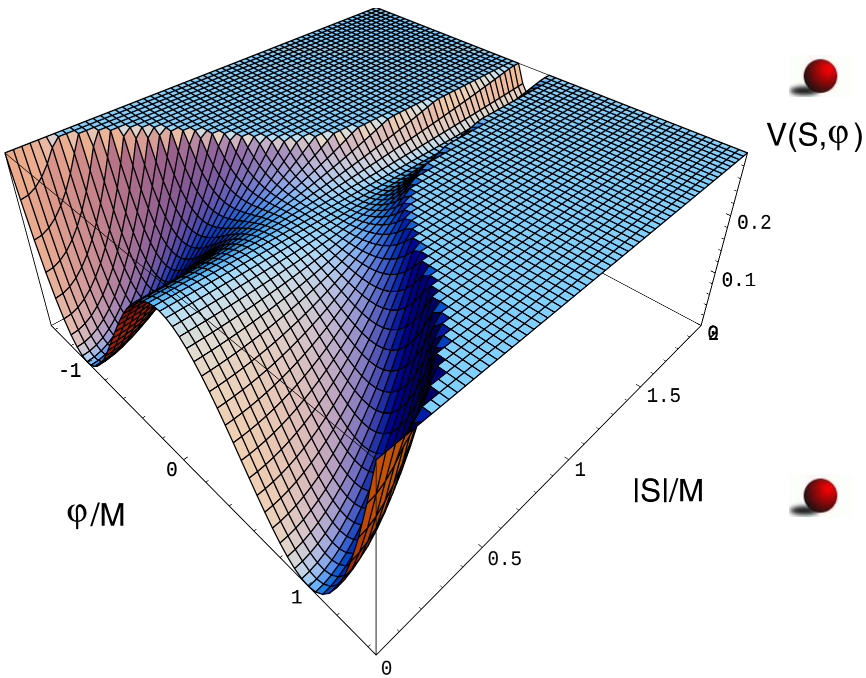

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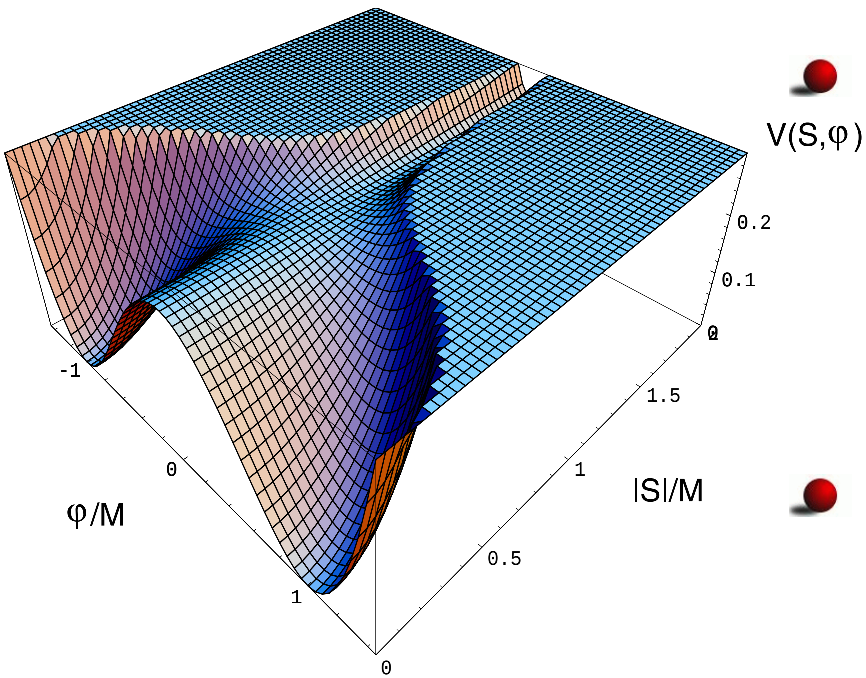

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RJ 98; *et al.* 03

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- $\mathbf{G} \xrightarrow{\text{Shifted Inflation}} \mathbf{3_c\, 2_L\, 1_Y \rightarrow 3_c\, 1_Q}$

RJ, S. Khalil, G. Lazarides, Q. Shafi

Standard hybrid inflation

- SSB patterns (examples)
  - $SO(10) \stackrel{\textbf{Monopoles}}{\longrightarrow}$
    $$\mathrm{SU(3)_c \times SU(2)_L \times SU(2)_R \times U(1)_{B-L}} \stackrel{\textbf{Inflation+Strings}}{\longrightarrow}$$
    $$\mathrm{SU(3)_c \times SU(2)_L \times U(1)_Y \times Z_2 \longrightarrow SU(3)_c \times U(1)_Q \times Z_2}$$
    $$\Phi, \bar{\Phi} = 126, 1\bar{2}6$$
  - $E(6) \stackrel{\textbf{Monopoles}}{\longrightarrow}$
    $$\mathrm{SU(3) \times SU(2)_L \times U(1)_R \times U(1)_{B-L}} \stackrel{\textbf{Inflation+Strings}}{\longrightarrow}$$
    $$\mathrm{SU(3)_c \times SU(2)_L \times U(1)_Y \longrightarrow SU(3)_c \times U(1)_Q}$$
    $$\Phi, \bar{\Phi} = 27, 2\bar{7}$$

CMB anisotropies

RJ & MP 05

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- $$V_{infl} = \kappa^2 M^4 \left[1 + \frac{\kappa^2 N}{32\pi^2} \left[2 \ln\left(\frac{4\kappa^2 |S|^2}{\Lambda^2}\right) + (z+1)^2 \ln(1 + z^{-1}) + (z-1)^2 \ln(1 - z^{-1}) \right] + \frac{|S|^4}{2 m_p^4} + \frac{|a|^2 |S|^2}{m_p^2} \right] + \kappa A m_{3/2} M^2 |S|$$

$z = |S|^2 / M^2$, $A = 4 \cos(\arg \mu - \arg S)$

CMB anisotropies

RJ & MP 05

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  WMAP $\Rightarrow \left(\frac{\delta T}{T}\right)_{\rm cs} / \left(\frac{\delta T}{T}\right)_{\rm tot} < 0.1$ Pogosian *et al.* 2003

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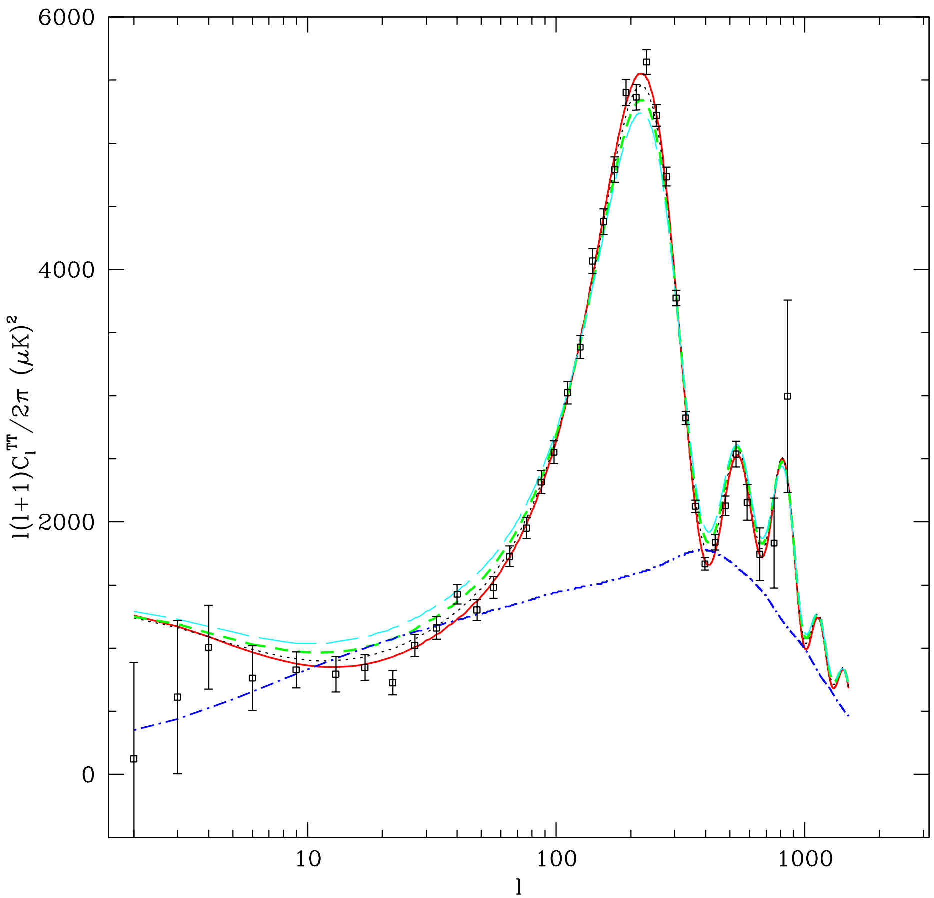
- WMAP data constrain $M(\kappa)$

CMB anisotropies

WMAP data do not exclude $\sim 10\%$ string contribution

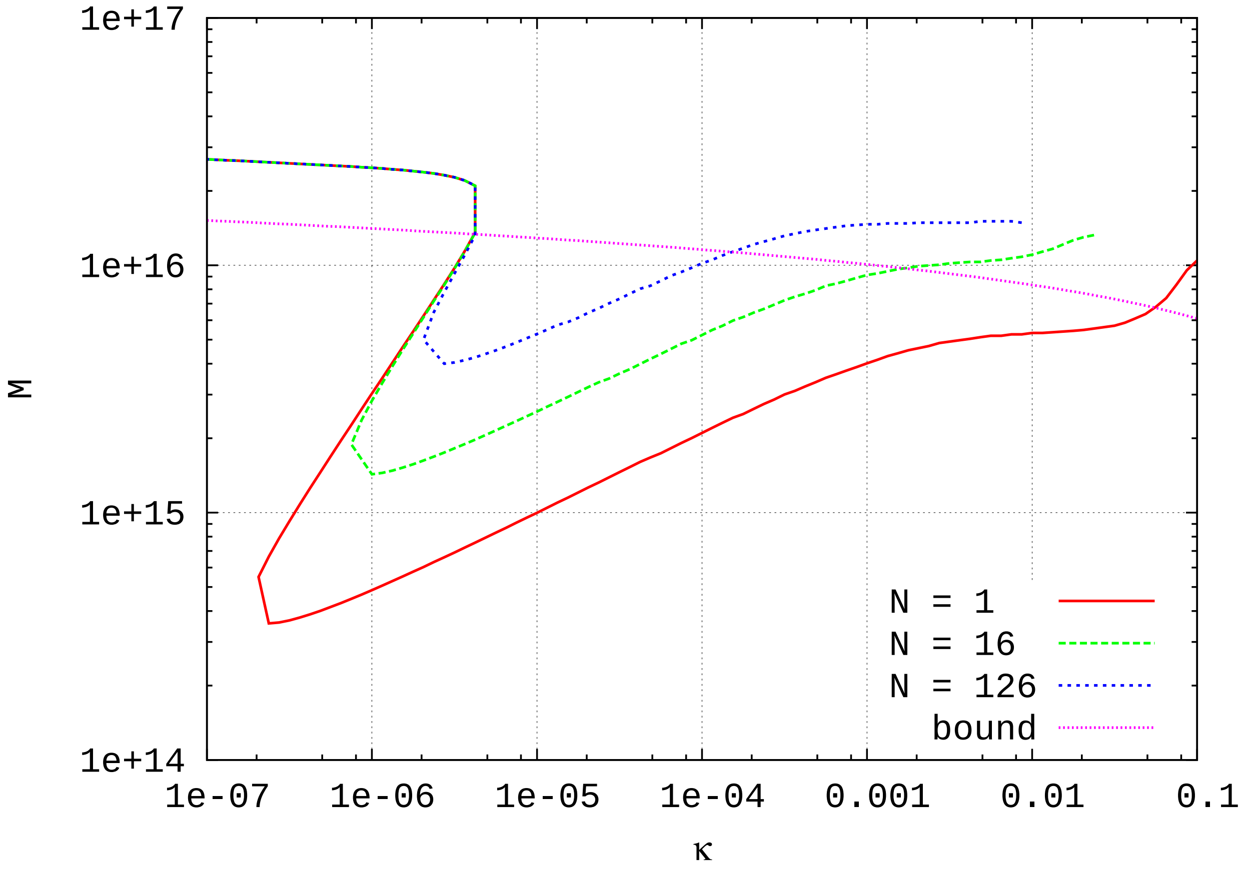


The CMB power spectrum predicted by cosmic strings (blue) does not coincide with the spectrum observed by WMAP which practically coincides with the inflationary predictions (red). **Inflation with $< 10\%$ string contribution (green)** also coincide. (From Pogosian *et al.*, 2003.)

CMB anisotropies

RJ & MP 05

SSB scale M as function of κ



CMB anisotropies

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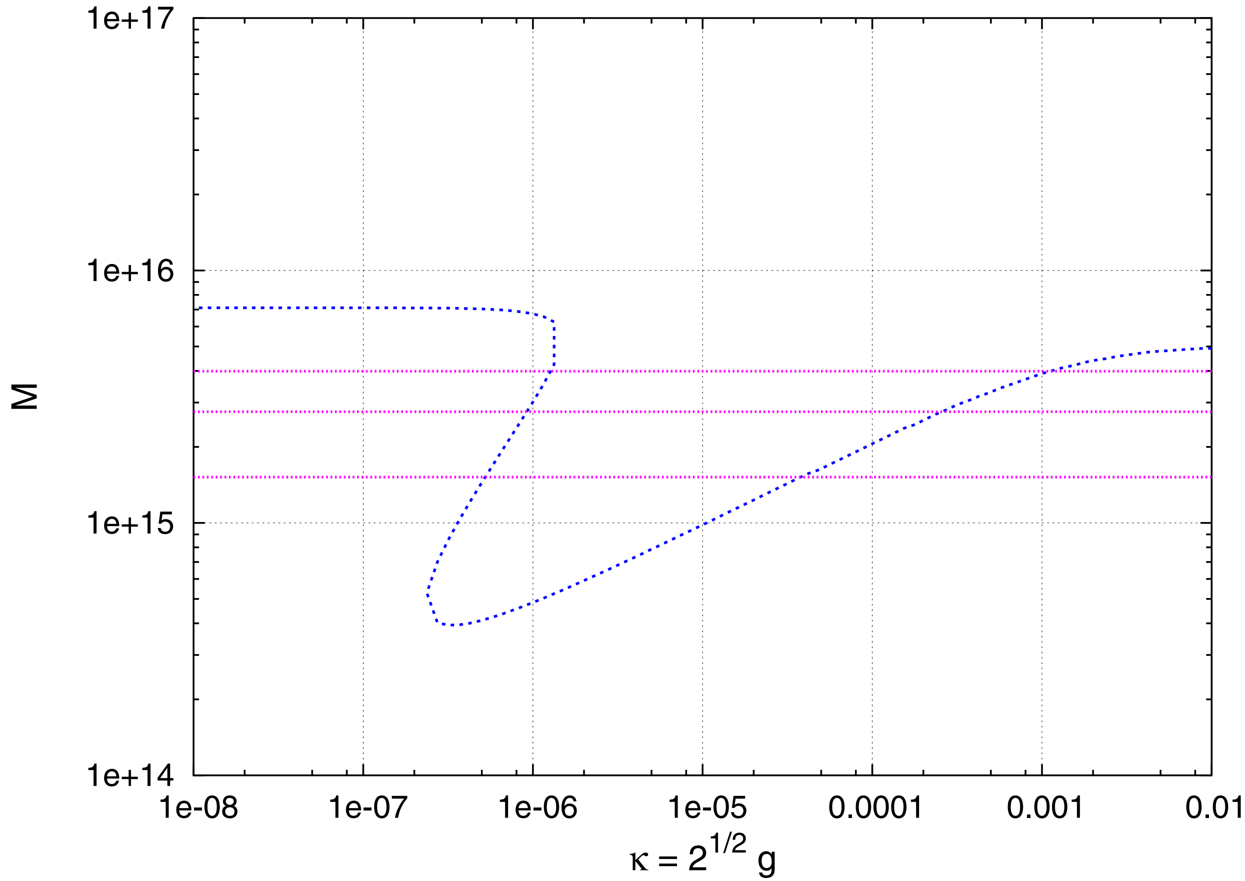
$M(\kappa)$ for strings in the Bogomolny limit (P-term inflation)



CMB anisotropies

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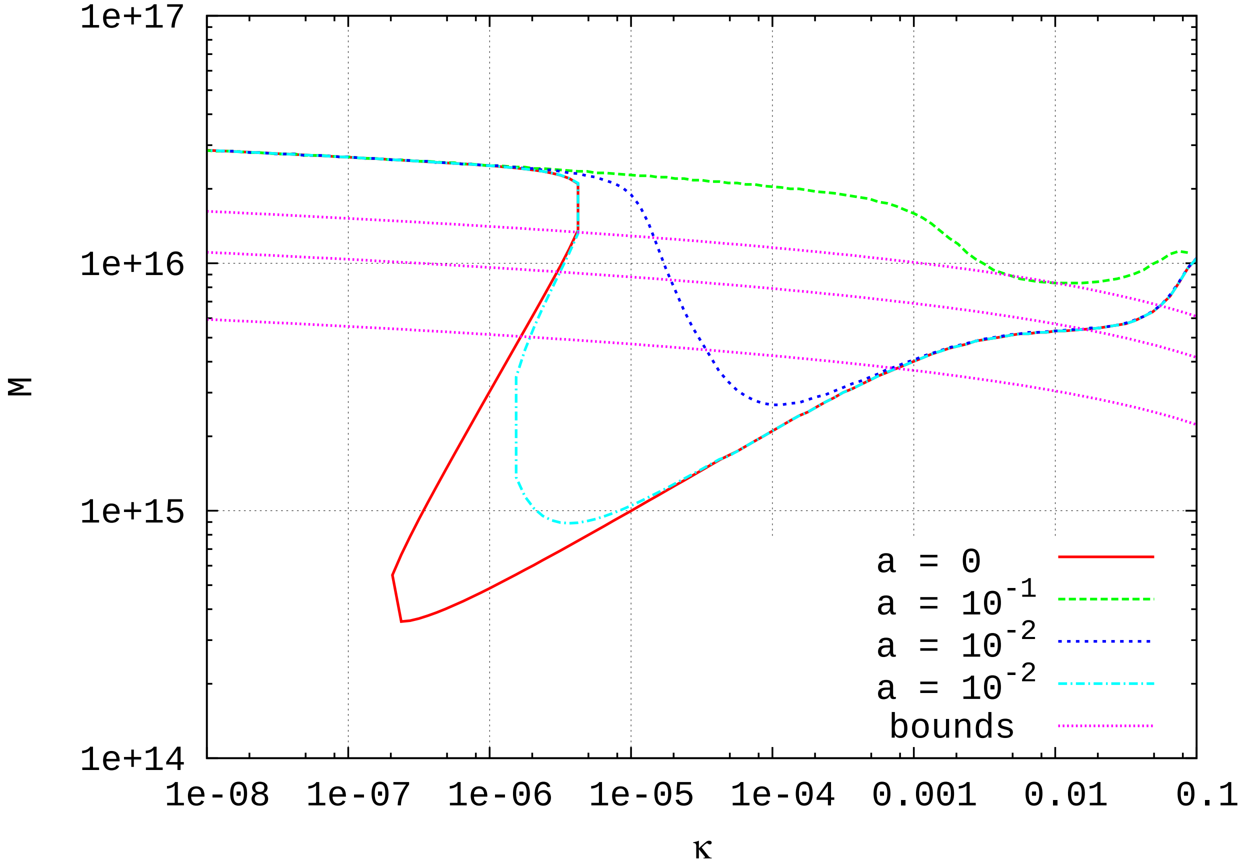
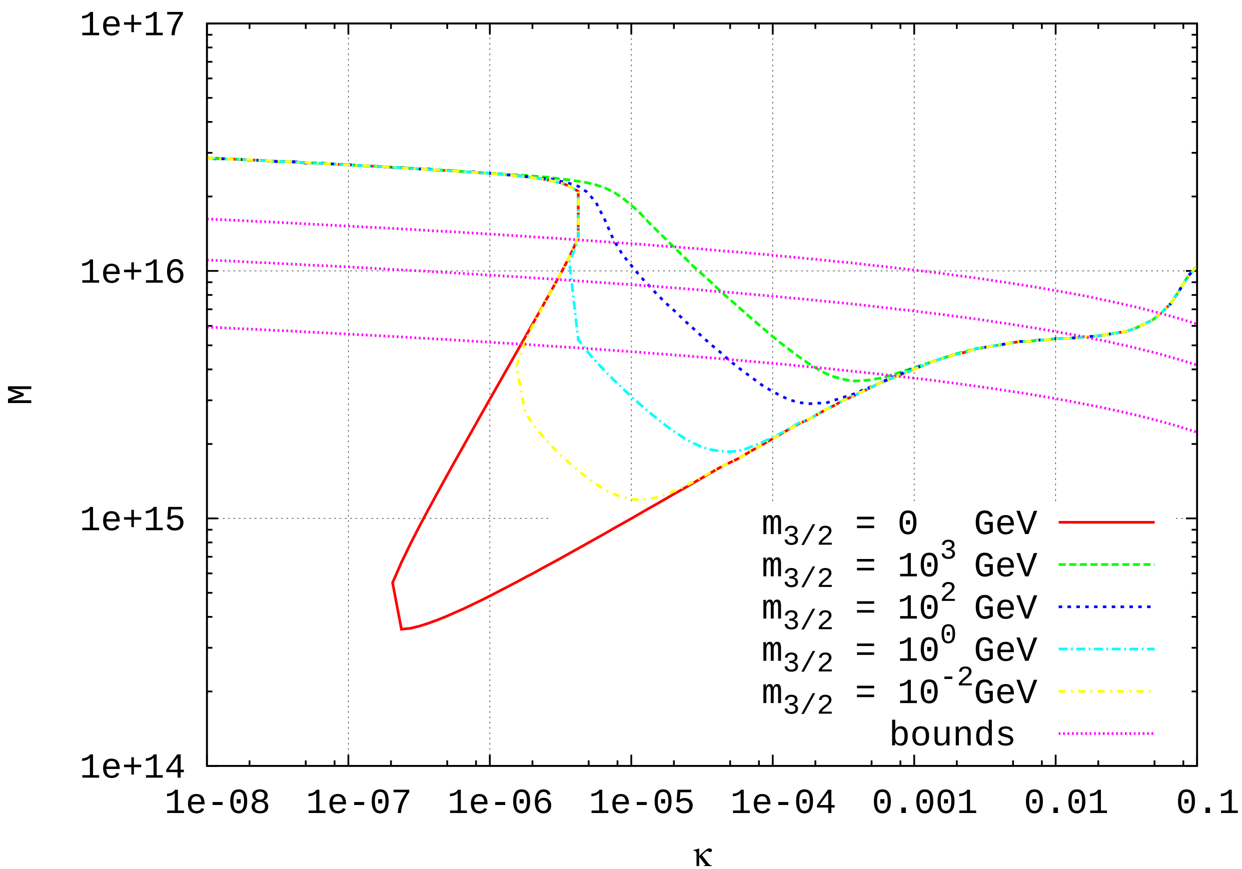
$M(\kappa)$ with Hubble induced mass term included



CMB anisotropies

$M(\kappa)$ with A-term included

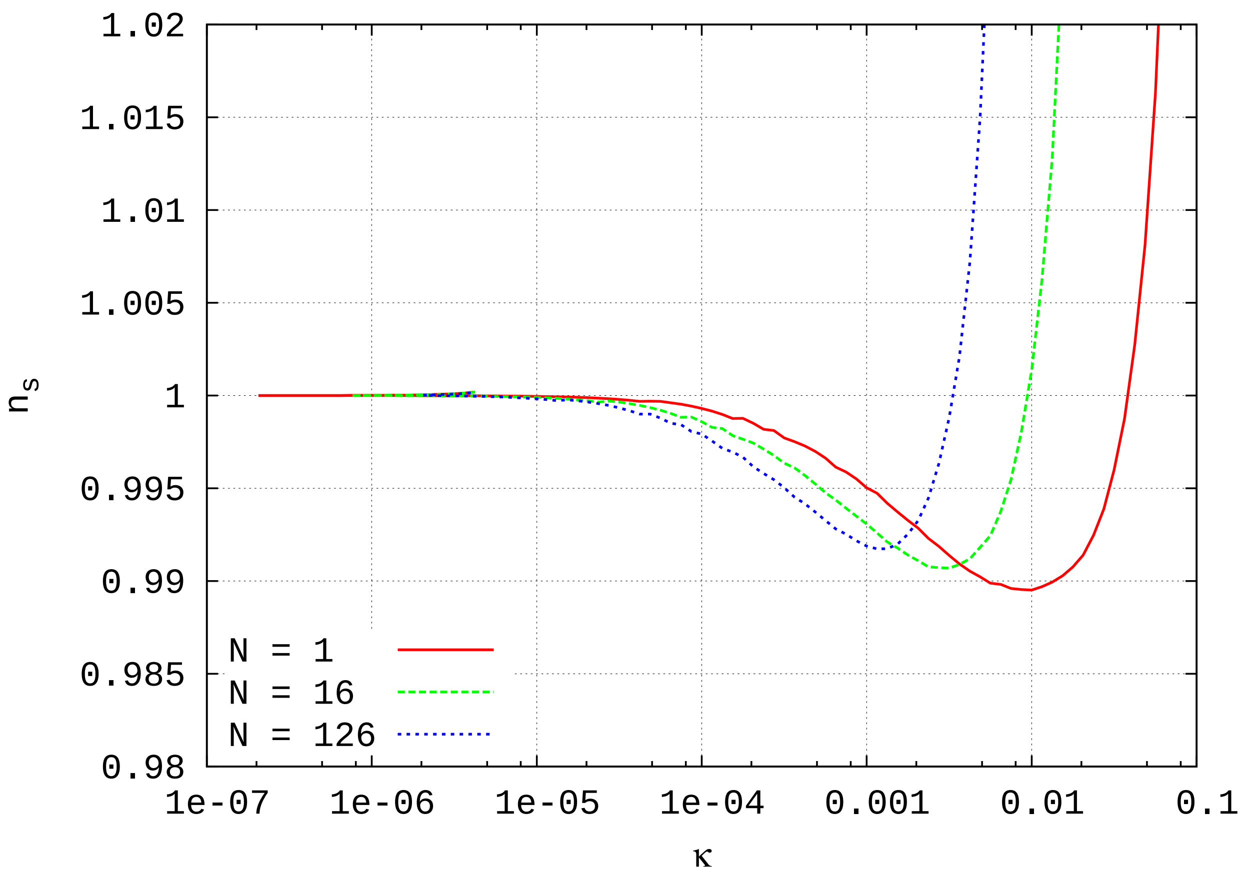


CMB anisotropies

RJ & MP 05

Spectral Index

(WMAP: $n = 0.99 \pm 0.04$)

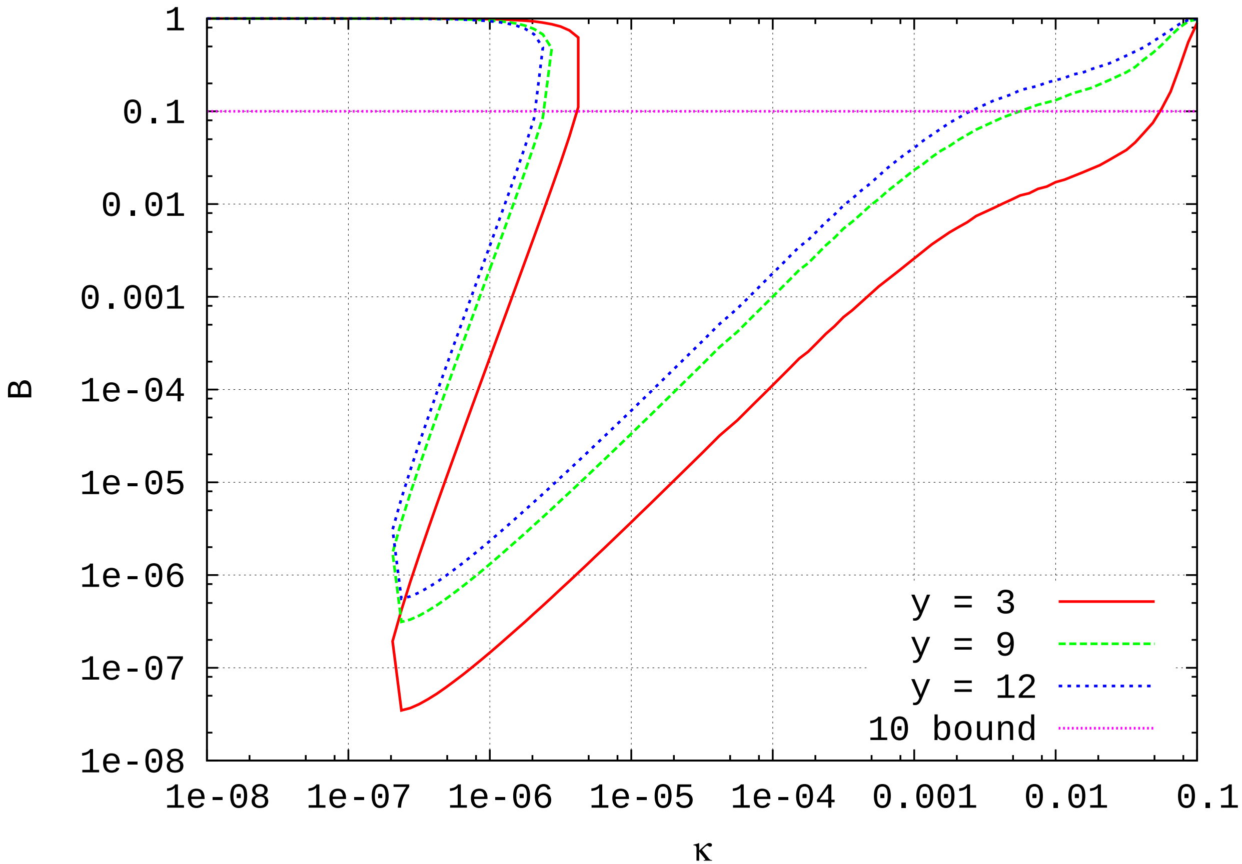


CMB anisotropies

RJ & MP 05

Cosmic string contribution

$$B = (\delta T/T)_{\rm cs}/(\delta T/T)_{\rm tot}$$



Leptogenesis

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$\rightsquigarrow$ B-L cosmic strings form a the end of inflation

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- During reheating — Lazarides & Shafi 91
  - $n_L/s \propto T_R(M(\kappa), M_{N_i})\,\epsilon_i/m_\Phi$

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- From B-L string decay — RJ 96
  - $n_L/s \propto M(\kappa), M_{N_i}, \epsilon_i, m_X$

Leptogenesis

Which scenario is most efficient ?

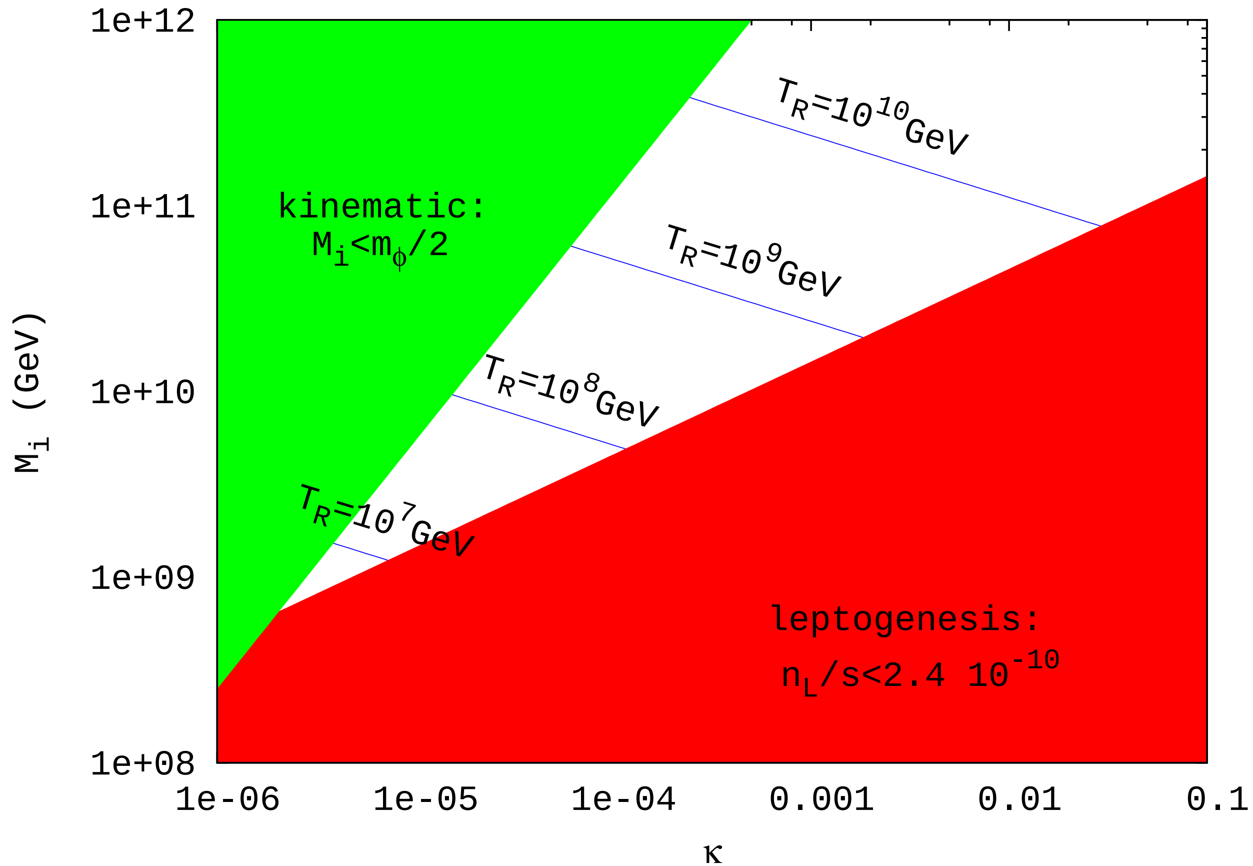
- We distinguish three cases:

  $M_{N_1} <> m_\phi/2$ and $M_{N_1} <> T_R$

Leptogenesis

RJ & MP 05

Case 1: $M_{N_1} < m_\phi/2$



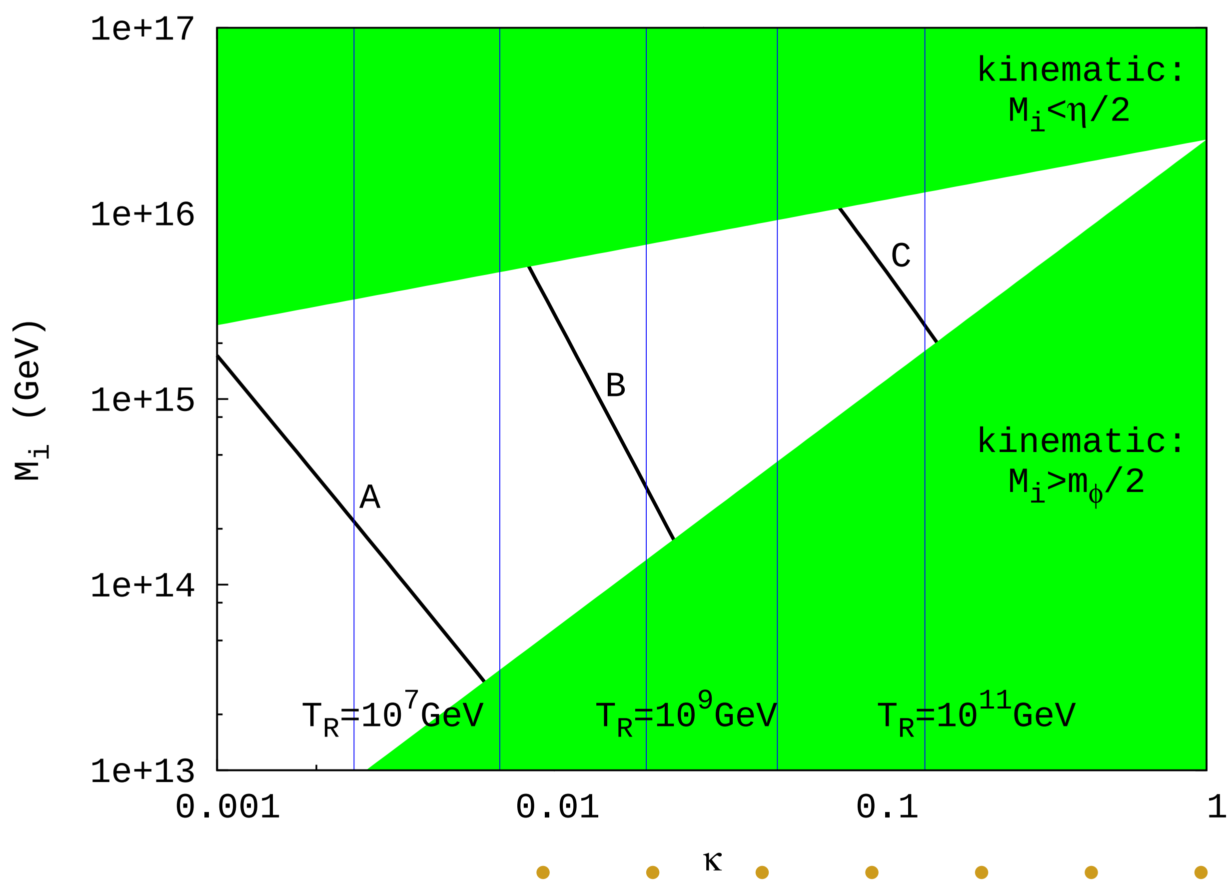
M_N versus κ for successful leptogenesis during reheating.

Parameter space for strings similar when $f_X \sim 1$. Otherwise the string contribution is subdominant.

Leptogenesis

RJ & MP 05

Case 2: $M_{N_i} > m_\phi/2 \; \forall i$ (no contribution from reheating) and $M_1 > T_R$ (no wash out). Reheating is gravitational or via Higgs(inos) production (μ-term).

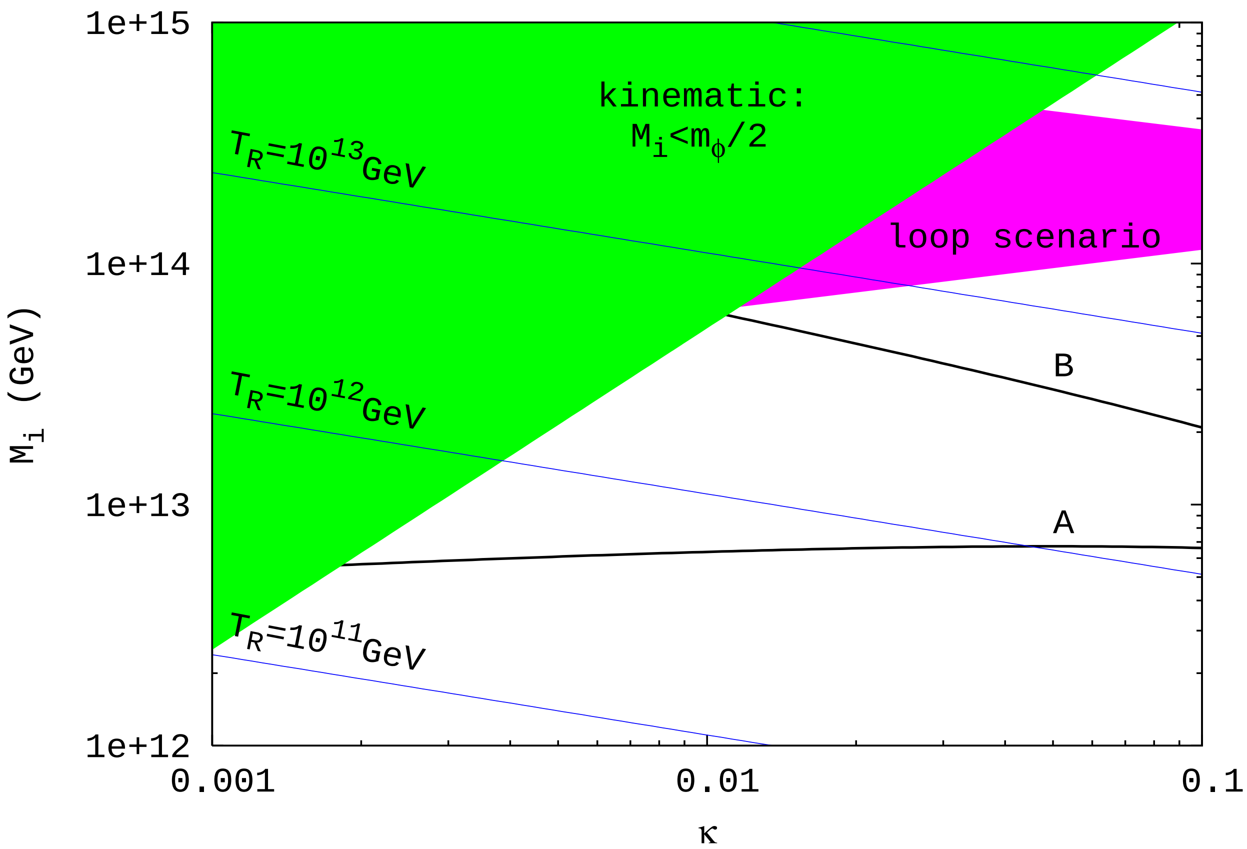


M_N versus κ for successful leptogenesis from B-L string decay.

Leptogenesis

RJ & MP 05

Case 3: $M_1 < T_R$ (some wash out).



M_N versus κ for successful leptogenesis from B-L string decay.

There is also a thermal contribution.

Conclusions

- Standard hybrid inflation predicts the formation of cosmic strings (F-term, D-term, Brane)
- CMB: The string contribution agrees with the data for most of the parameter space
- Leptogenesis after standard hybrid inflation in SUSY GUTs, two scenarios: from reheating at the end of inflation and cosmic string decay
- The string contribution is subdominant when decay of inflaton into N is possible. When reheating is gravitational or via Higgs(inos) production (μ-term), string scenario only; large parameter space consistent with gravitino problem.