Inflationary cosmology in the central region of string/M-theory moduli Space

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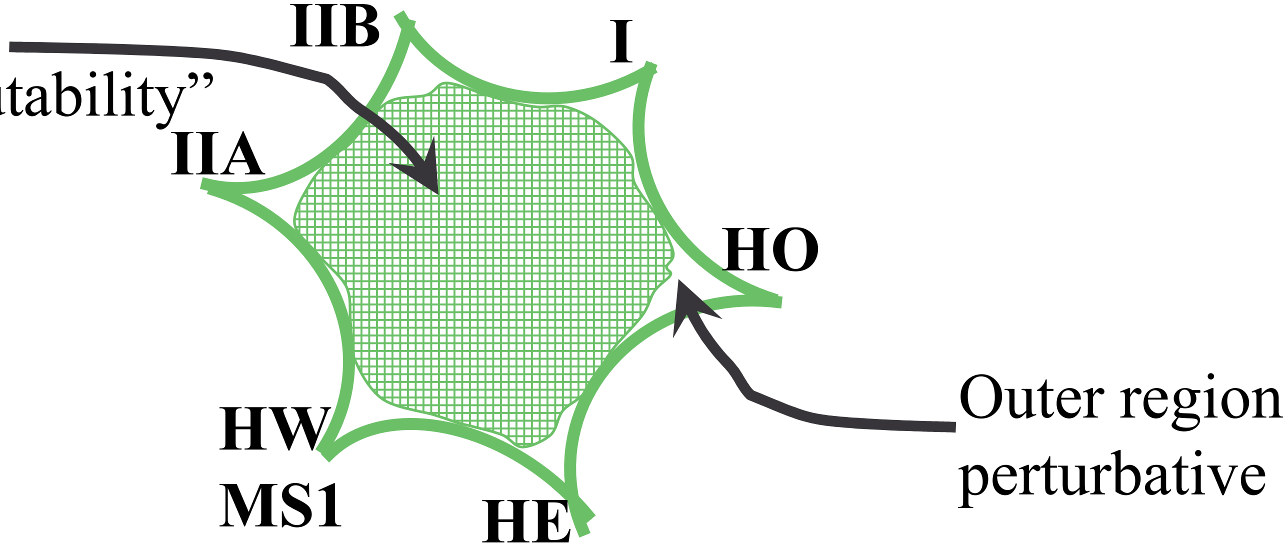
hep-th/0205042
hep-th/02xxxx
with S. de Alwis and E. Novak
PRL 87 (2001), hep-th/0106174
PRD 64 (2001), hep-th/0002087
with S. de Alwis

- Outer region of moduli space: problems!
- Central region: parametrization with N=1 SUGRA
- Scales & shape of central region potential
- Inflation: constraints & predictions

String Moduli Space



Requirements

- D=4
- N=1 SUSY ➔ N=0
- $CC<(m_{3/2})^4$
- SM (will not discuss)
- Volume/Coupling moduli
  T S

Perturbative theories =
cosmological disaster

- **massless moduli**
- **Gravity ≠ Einstein’s**
- **Inflation blocked**

Central Region

Our proposal:

- Parametrization with D=4, N=1 SUGRA
- Stabilization by SNP effects @ string scale
- Continuously adjustable parameter
- SUSY breaking @ lower scale by FT effects
- PCCP o.k after SUSY breaking

Scales & Shape of Moduli Potential

- The width of the central region

In effective 4D theory:
moduli kinetic terms multiplied by $M_S^8 V_6$ ($M_{11}^9 V_7$ in M-theory).
Curvature term multiplied by same factors
"Calibrate" using 4D Newton's constant $8\pi G_N = m_p^{-2}$

$$\Gamma = \tfrac{1}{2}\int d^4x \left\{ \underline{m_p^2} \sqrt{-g} R + \underline{m_p^2} \partial\psi \, \partial\psi \right\}$$

→ Typical distances are order one in units of m_p

- The scale of the potential

$$W \approx M_S^3 \Rightarrow V \approx M_S^6 / m_p^2 \equiv \Lambda^4$$

NO VOLUME FACTORS!!!

Banks

Numerical examples:

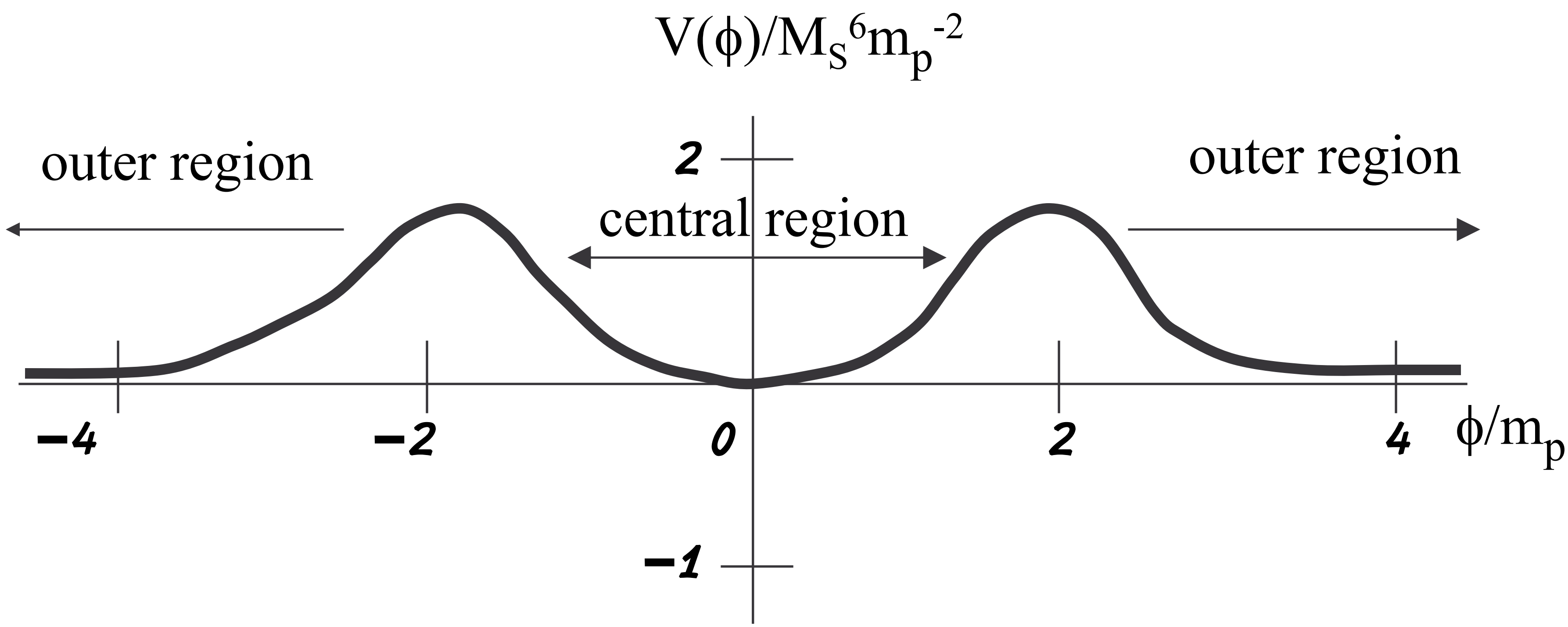
$$\Lambda_I = 8.6\times 10^{16}\, GeV \left(\frac{\alpha_{YM}}{1/25}\right)^{3/4} g^{3/4}$$

$$\Lambda_{HW} = 7.6\times 10^{16}\, GeV \left(\frac{\alpha_{YM}}{1/25}\right)^{-1/4} \left(4 M_{GUT} V_6^{1/6}\right)^{-3/2}$$

$$\Gamma = \int d^4x \left\{ \tfrac{1}{2} m_p^2 \partial\psi\, \partial\psi - \Lambda^4 V(\psi) \right\}$$

$$= \int d^4x \left\{ \tfrac{1}{2} \partial\phi\, \partial\phi - \Lambda^4 V(\phi / m_p) \right\}$$

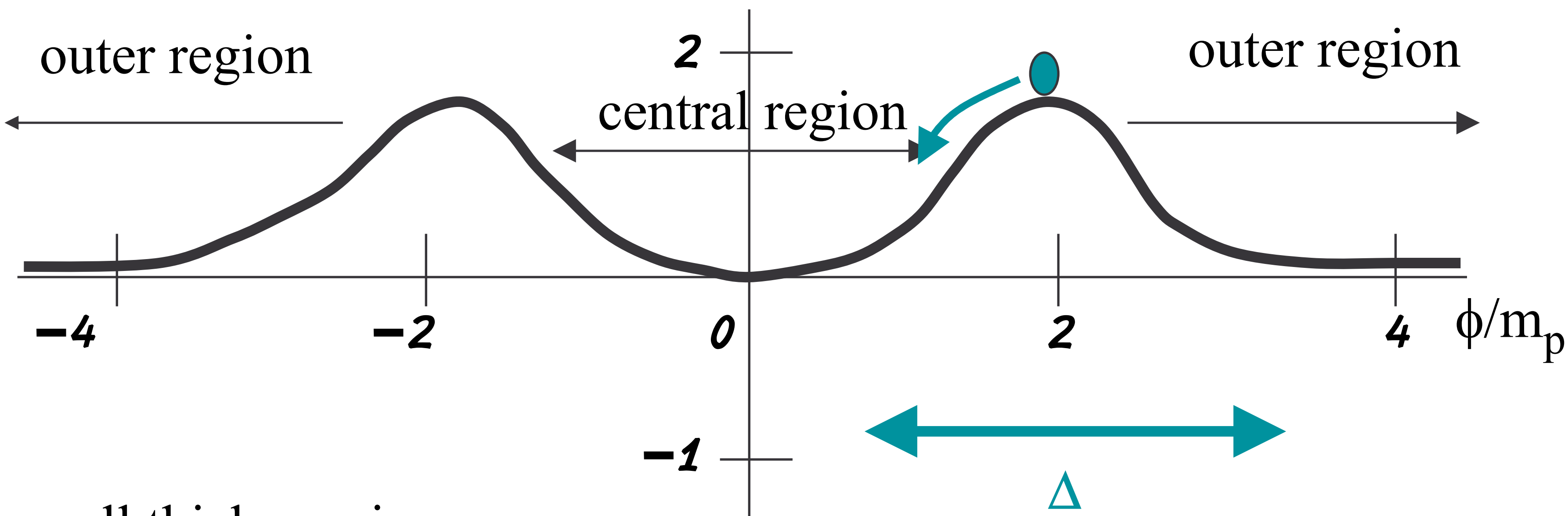
- The shape of the potential



zero CC min. & potential vanishes @ infinity ➔ intermediate max.

Inflation: constraints & predictions

- Topological inflation



δ– wall thickness in space

$\Delta/\delta \sim \Lambda^4$

$H^2 \sim 1/3\ \Lambda^4/m_p^2$

Inflation ⇔ $\delta H > 1$ ⇔ $\Delta > m_p$

•Sufficient inflation

Slow-roll parameters $\varepsilon \sim 2\frac{m_p^2}{\mu^4}(\phi - \phi_{\max})^2, \eta \sim V''(\phi_{\max})$

The "small" parameter $\mu^2 = \frac{2m_p^2}{|V''(\phi_{\max})|}$

Number of efolds $N(\phi, \phi_{end}) = \frac{1}{\sqrt{2}m_p} \int_{\phi}^{\phi_{end}} \frac{1}{\sqrt{\varepsilon(\phi)}} d\phi$

Sufficient inflation $\phi_{init} - \phi_{\max} \cong \mu \, Exp\left(-\left[120(m_p/\mu)^2\right]\right)$

Quantum fluct. not too large $\phi_{init} - \phi_{\max} \succ \frac{H}{2\pi} \Rightarrow V''(\phi_{\max}) \prec 1/6$

•CMB anisotropies and the string scale

$$\phi_{CMB} - \phi_{\max} = \mu\, Exp\left(-\left[100(m_p/\mu)^2\right]\right) \qquad N(\phi_{CMB}, \phi_{end}) = 50$$

$$P_\varsigma^{1/2} = \frac{\sqrt{3}}{2\pi}\frac{\mu\Lambda^2}{m_p^3} Exp\left(\left[100(m_p/\mu)^2\right]\right) \qquad P_\varsigma^{1/2} = \frac{\sqrt{3}}{2\pi}\frac{1}{m_p^3}\frac{V^{3/2}}{V'} = \frac{15}{2}\frac{\delta\rho}{\rho}$$

$$M_S^3 / m_p = \Lambda^2 = \frac{4\pi}{\sqrt{3}} P_\varsigma^{1/2} \frac{m_p^3}{\mu} Exp\left(-\left[100(m_p/\mu)^2\right]\right)$$

$$\Lambda^2 \cong 6.5\times 10^{16}\, GeV\left(V''(\phi_{\max})/2\right)^{1/4} Exp\left(-\left[25V''(\phi_{\max})\right]\right)$$

For consistency need V''~1/25

For our model

$$\varepsilon_{CMB} \propto (V'/V)^2 \sim 0$$

$$\eta_{CMB} \cong V''(\phi_{\max})$$

$$n_S = 1 - 4\varepsilon_{CMB} + 2\eta_{CMB}$$
$$r = 13.7\varepsilon_{CMB}$$

➔➔

$$n_S = .92 - .08(25V''(\phi_{\max}) - 1)$$
$$r \cong 0$$

1/3 < 25V’’ < 3 ➔

$$.76 \prec n_S \prec .97$$

$$r \cong 0$$

If consistent:

$$M_S \cong 1.7 \times 10^{17}\, GeV \left(\frac{P_\varsigma^{1/2}}{10^{-4}} \right)^{1/3} (1 - n_S)^{-1/6} e^{-\frac{25}{3}(1-n_S)}$$

Summary and prospects

- Scenario: Stabilization in Central region
- Consistent cosmology:
  - scaling arguments
  - Curvature of potential needs to be “smallish”
- Predictions for CMB

❖ Calculate ? possible to some extent