Title: Gravitational Wave constraints on multi-brane inflation

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Abstract: A class of non-canonical inflationary models is identified, where the leading-order contribution to the non-Gaussianity of the curvature perturbation is determined by the sound speed of the fluctuations in the inflaton field. Included in this class of models is the effective action for multiple coincident branes in the finite n limit. The action for this configuration is determined using a powerful iterative technique, based upon the fundamental representation of SU(2). In principle the upper bounds on the tensor-scalar ratio that arise in the standard, single-brane DBI inflationary scenario can be relaxed in such multi-brane configurations if a large and detectable non-Gaussianity is generated. Moreover models with a small number of coincident branes could generate a gravitational wave background that will be observable to future experiments.

Gravitational wave constraints on multi brane inflation

Ian Huston

School of Mathematical Sciences, Queen Mary, University of London

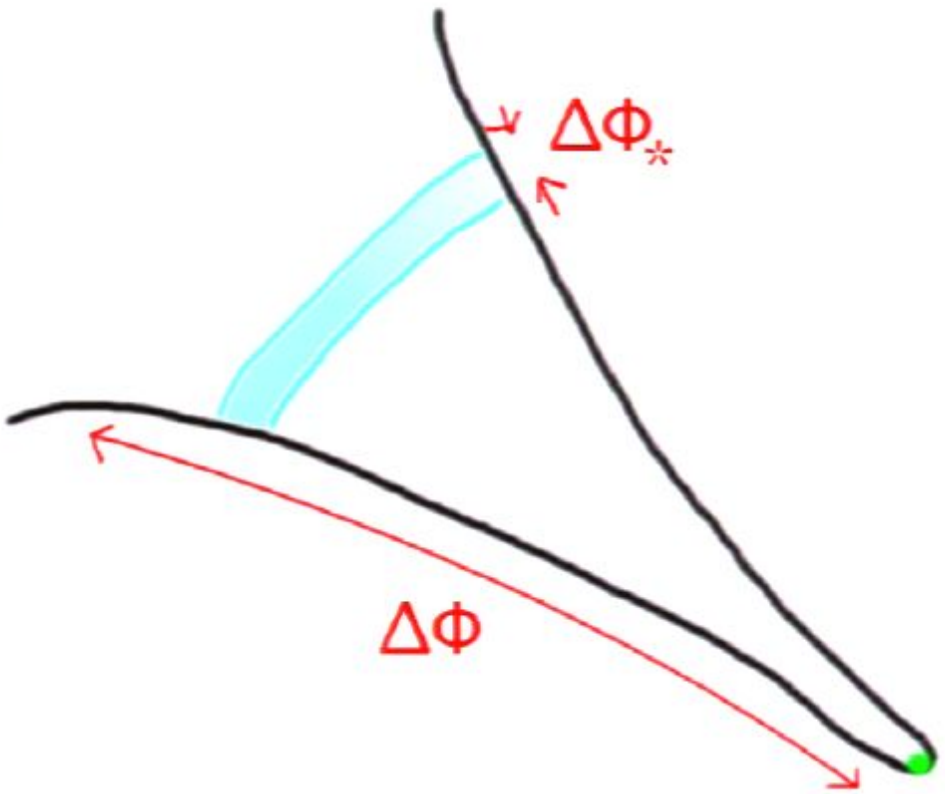
Based on IH, J.E.Lidsey, Steven Thomas & John Ward,

JCAP05(2008)016, *arxiv:0802.0398v2*

Queen Mary
University of London

Normal DBI in throat

J.E.Lidsey & IH *arxiv:0705.0240*:



We considered observable changes $\Delta\rho_*$:

$$\Delta\phi_* \quad < \quad \Delta\phi$$

Used observables to place tighter constraints on r.

Found...

$$r < 10^{-7} \text{ BUT}$$
$$r > \frac{1}{8}(1 - n_s) > 0.002$$

A few definitions

Action

$$S = \int d^4x \sqrt{|g|} \left[\frac{M_{\rm P}^2}{2} R + P(\phi, X) \right]$$

Non-Gaussianity[1]: $f_{\rm NL} = -\frac{35}{108}\left(\frac{1}{c_s^2} - 1\right) + \frac{5}{81}\left(\frac{1}{c_s^2} - 1 - 2\Lambda\right)$

where: $c_s^2 = \frac{P_{,X}}{P_{,X} + 2XP_{,XX}}$; $\Lambda \equiv \frac{X^2 P_{,XX} + \frac{2}{3} X^3 P_{,XXX}}{XP_{,X} + 2X^2 P_{,XX}}$

[1] WMAP convention

Evading the bounds

Standard DBI:

- $c_s P_{,X} = 1$
- $\Lambda = \frac{1}{2}\left(\frac{1}{c_s^2} - 1\right)$
- $f_{\rm NL} \propto \frac{1}{c_s^2}$

We want:

- $c_s P_{,X} \gg 1$
- $\Lambda = \frac{1}{\alpha}\left(\frac{1}{c_s^2} - 1\right)$
- $f_{\rm NL} \propto \frac{1}{c_s^2}$

Class of actions

$$P(\phi, X) = f_1(\phi)\left[1 - f_2(\phi)X\right]^m - f_3(\phi)$$

where $m = \frac{2(\alpha - 3)}{\alpha - 6}$.

Conditions required

LH bound now gives:

$$r < F(\phi)(-f_{\rm NL})^{1/2-m}$$

▸ Full eqn

Conditions

- Standard DBI is $m = \frac{1}{2}$
- To loosen bounds need $m < \frac{1}{2}$

Full LH bound

$$r_* < \frac{10}{(\Delta\mathcal{N})_*^2}\left(\frac{T_3}{\mathrm{Vol}(X_5)}\right)^{1/3}\left(\frac{h_*}{M_\mathrm{P}}\right)^{4/3}\frac{(-m)f_1 f_2}{\sqrt{2(1-m)}}\left(-\frac{f_\mathrm{NL}}{\beta}\right)^{\frac{1-2m}{2}}$$

Back

Conditions required

LH bound now gives:

$$r < F(\phi)(-f_{\rm NL})^{1/2-m}$$

▸ Full eqn

Conditions

- Standard DBI is $m = \frac{1}{2}$
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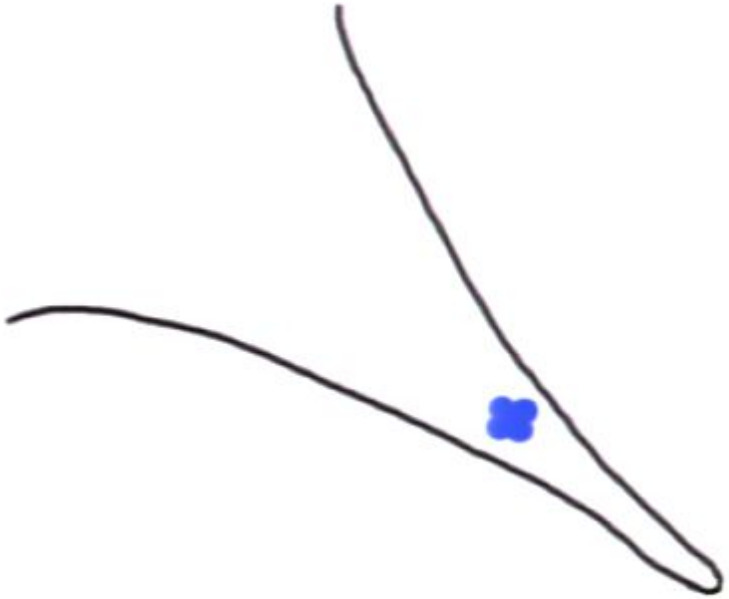
Coincident Brane Scenario

Thomas & Ward, *hep-th/0702229*:



- n coincident branes
- non-Abelian $U(n)$ structure
- finite n limit $(n < 10)$

New in our paper:

Recursive description of $P(X)$ for all n in terms of $n = 2$ case.

In our scheme?

Relativistic limit: $c_s^2 \ll 1$

Coincident brane action $\Rightarrow m = -\frac{1}{2}$

New looser bound

$$r < F(\phi)(-f_{\rm NL})$$

How many branes needed for detectable tensor signal?

Assuming tensor modes are observed with $r > 10^{-4}$:

$$n < 1 - 0.014 f_{\rm NL}$$

WMAP5 bound ($f_{\rm NL} > -150$) then gives:

$$n < 3.1 \Rightarrow n = 2 \text{ or } n = 3$$

- If $n \geq 4$ then no detectable tensor signal.
- Tensors undetectable for all multi-brane configurations if $f_{\rm NL} > -70$.
- This is for all known compactifications, could be avoided if new ones were found.

Looking forward

What have we learned?

- Class of actions that can loosen bound on r.
- Coincident brane scenario of T&W is part of this class.
- WMAP5 constrains models that generate detectable r to $n = 2$ or 3.

Future directions

- Motivates looking at specific working models, e.g. choose potential.
- Other UV theories in the general class of bound evading actions?
- Other DBI-like models helped by similar dependence on $f_{\rm NL}$?

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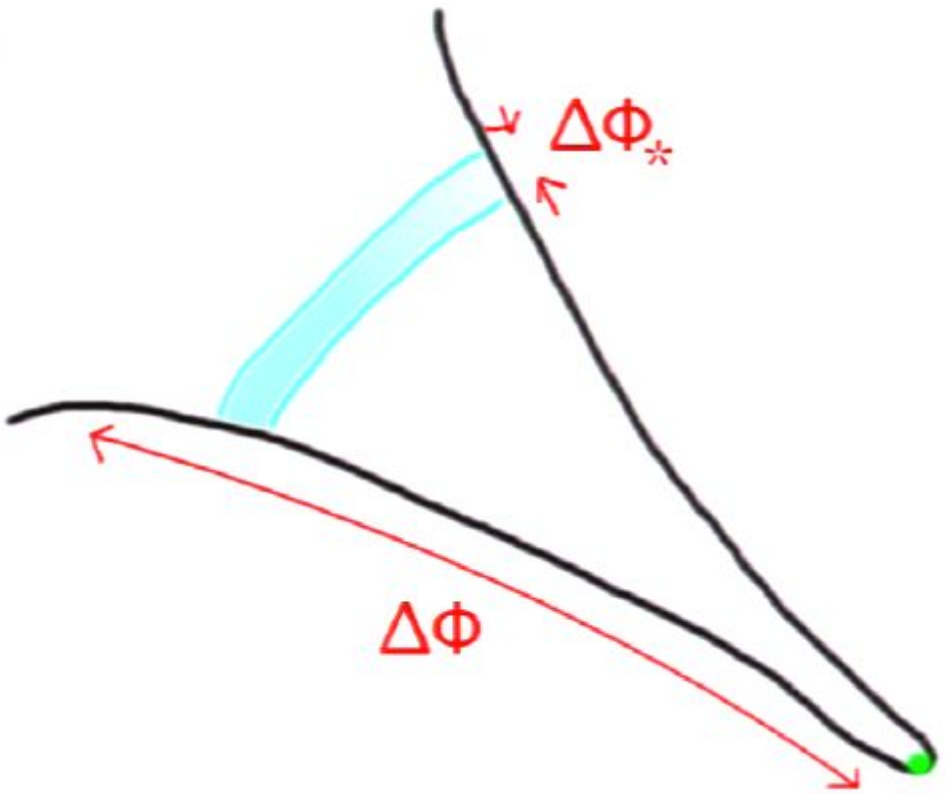
J.E.Lidsey & IH *arxiv:0705.0240*:



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