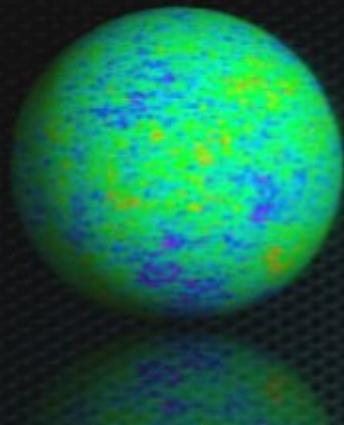


Title: Non-Gaussianities from modified initial states

Date: Jun 06, 2008 11:30 AM

URL: <http://pirsa.org/08060180>

Abstract: We consider the most general treatment of primordial non-Gaussianities, arising from modifying the initial state. Besides considering non-Gaussian effects due to subhorizon particle production, we parameterize the initial non-Gaussian features in terms of a Boundary Effective Field Theory (BEFT). Both effects contribute to the final result for the bispectrum, and we use this to put constraints on the initial state.



Towards Constraining the initial state using Non-Gaussianities

Daan Meerburg

University of Amsterdam, ITF-API

PASCOS 2008

MAIN MESSAGE

Initial state modifications always lead to
enfolded non-Gaussianities (NG)

BEFT gives **extra** contribution
(cor)related) [WIP]

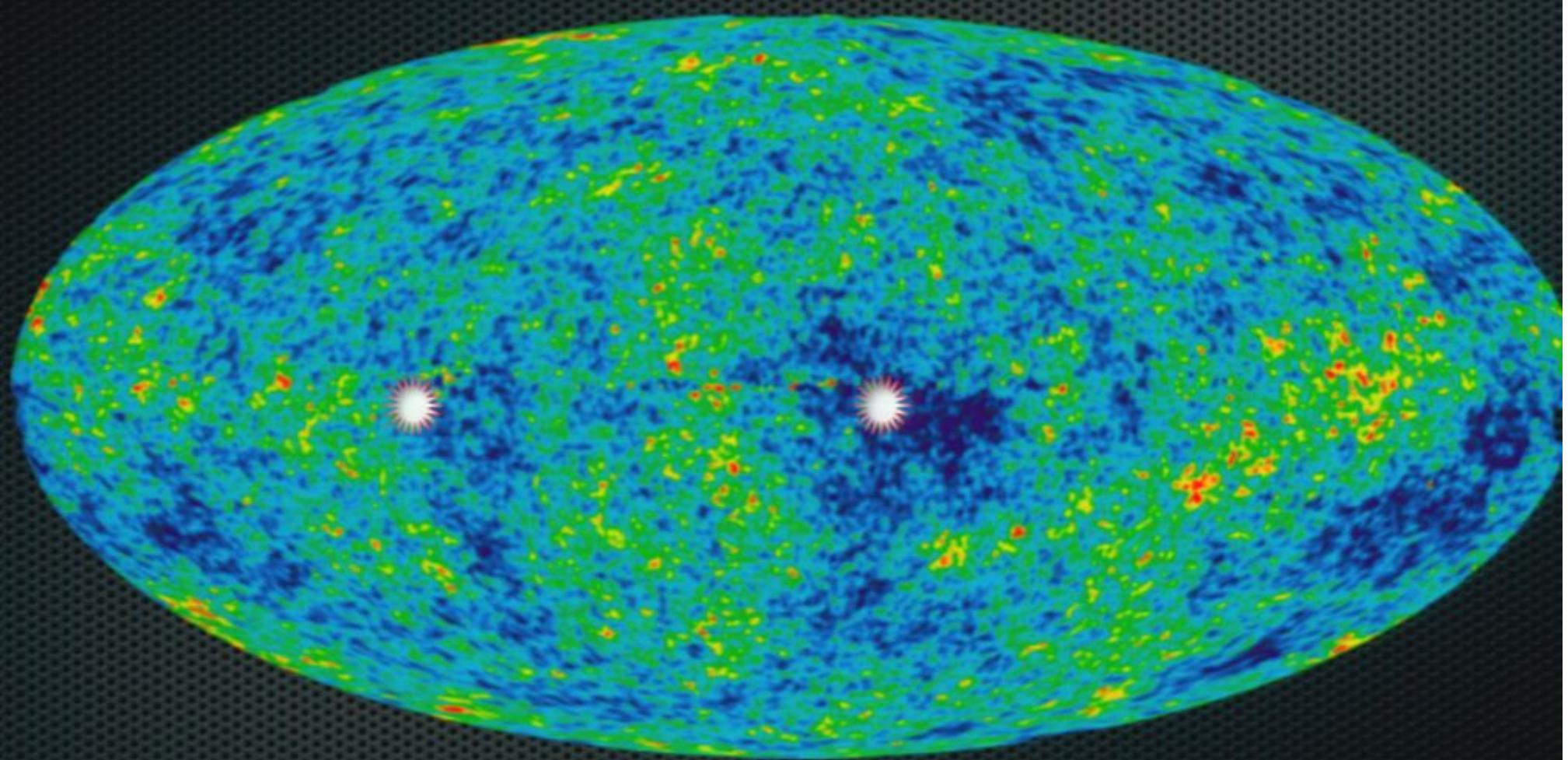
Construction of **enfolded template**

Bounding enfolded NG might strongly
constrain the initial state

OUTLINE

- ★ **Introduction**
- ★ **BEFT**
(Boundary Effective Field Theory)
- ★ **Non-Gaussianities**
- ★ **Non-Gaussian Shapes**
- ★ **Conclusions**

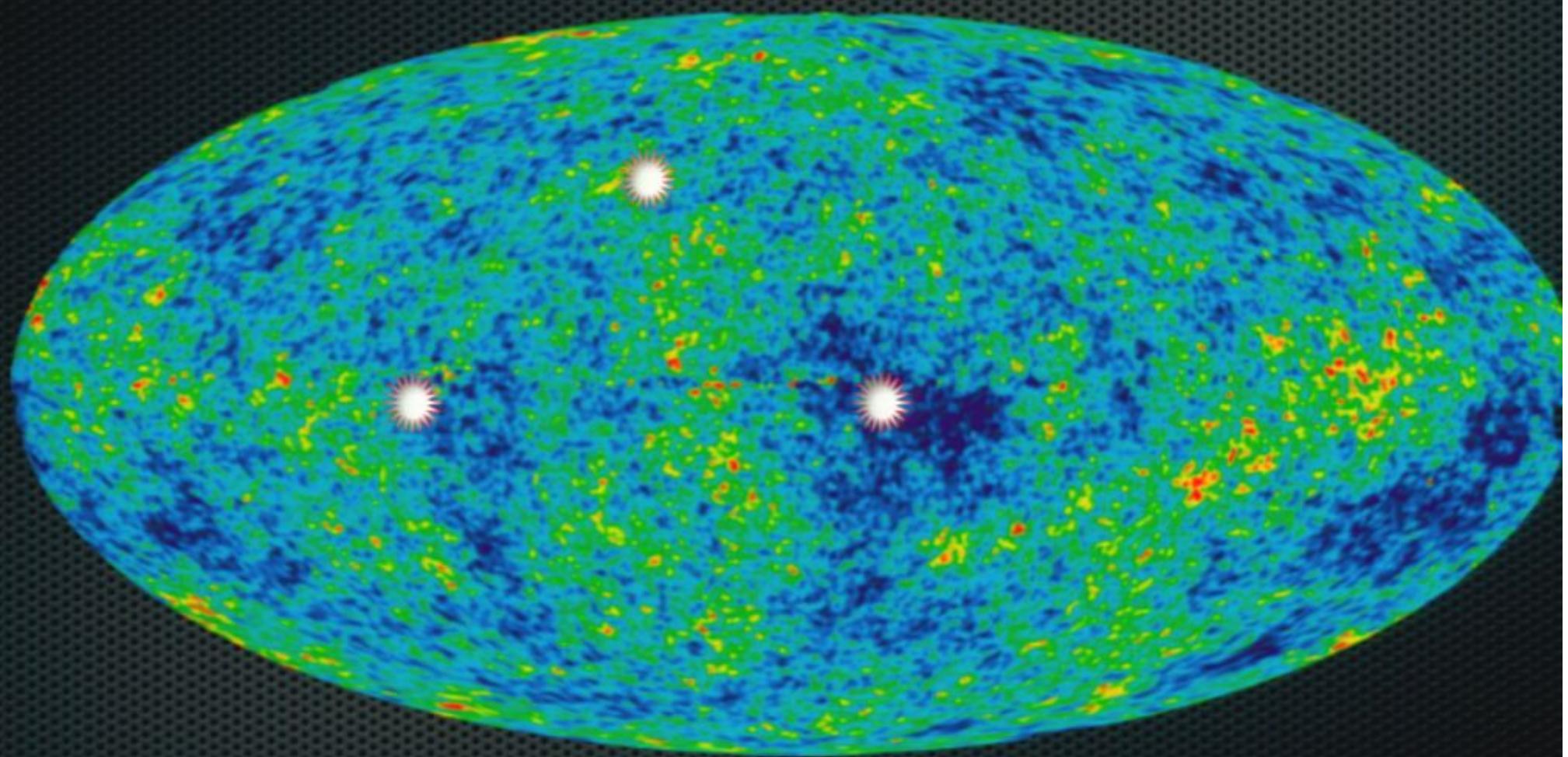
INTRODUCTION



$$T \leftrightarrow a_{lm}$$

$$\mathcal{C}_l$$

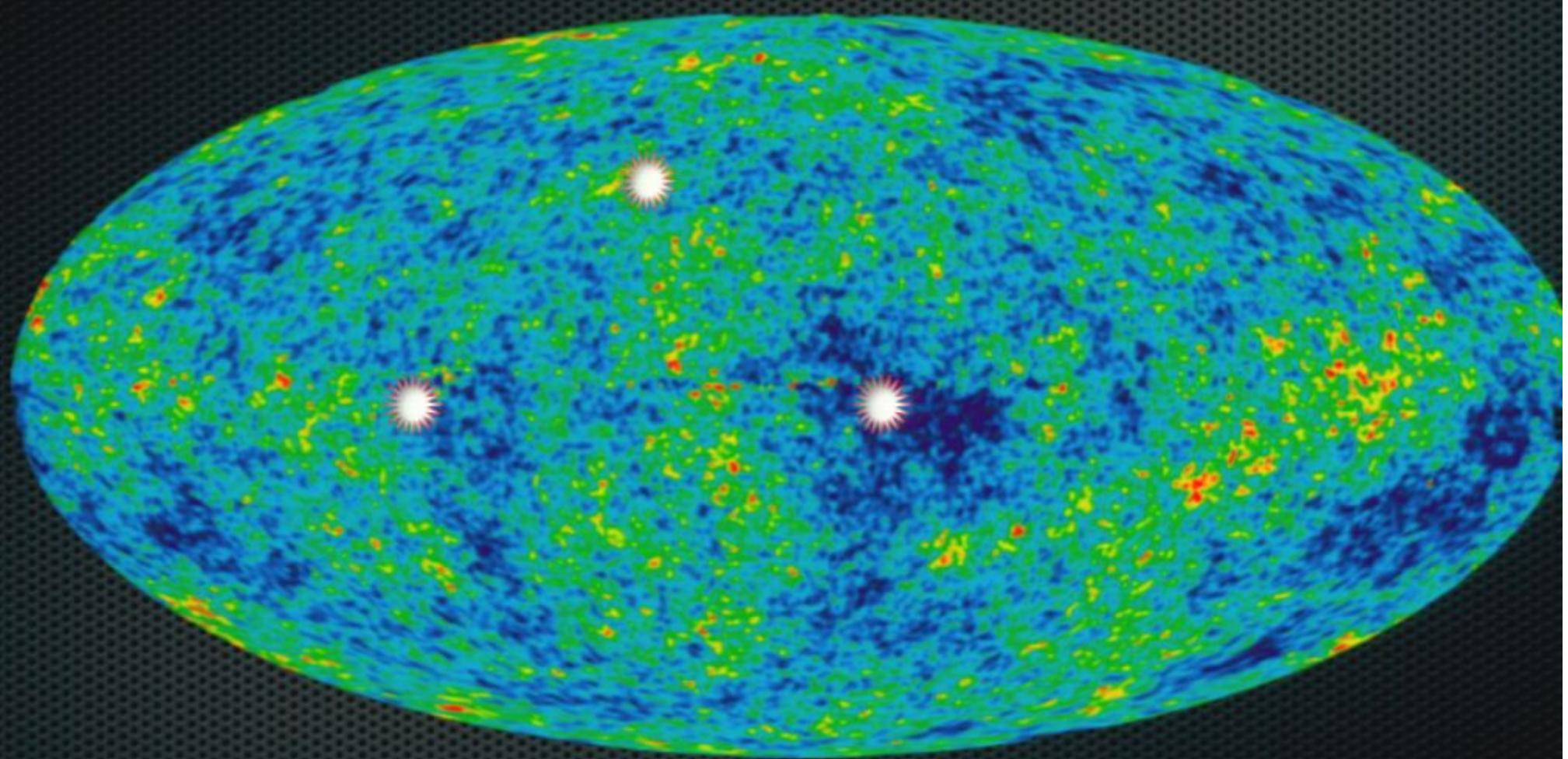
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$$\mathcal{B}_{l_1 l_2 l_3}$$

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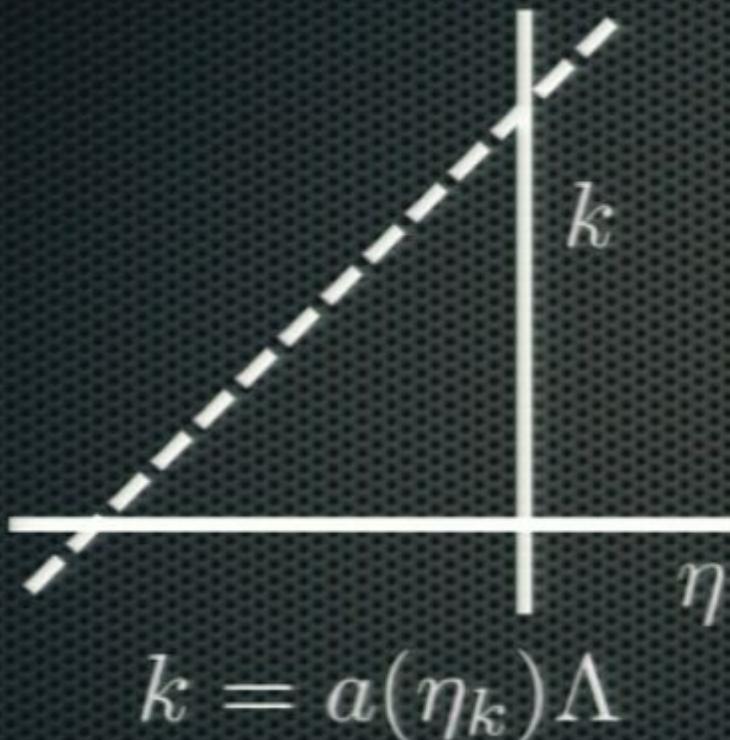
INTRODUCTION

$\mathcal{B}_{l_1 l_2 l_3}$

- ★ > Degrees of Freedom
- ★ Deviation from Random
- ★ Quantum fl. -> Inflation
- ★ Different Models, **Different Shapes**
- ★ Signature of Fundamental Physics

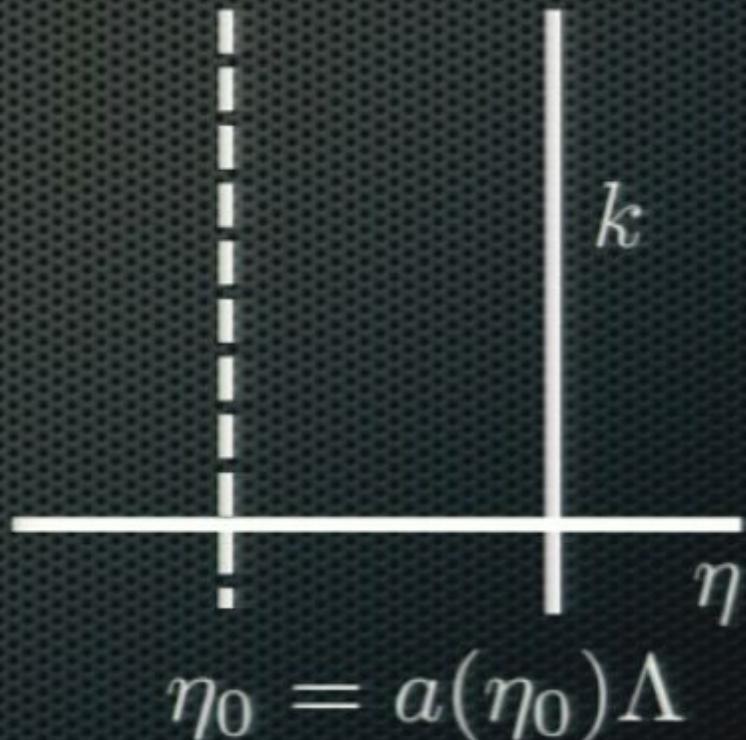
BEFT

2 Possibilities to set a Boundary
NPH **BEFT**



Danielsson 2002

Pirse: 08060180



Schalm, Shiu & v d Schaar 2005

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BEFT

In the language of Actions:

$$S_{\text{tot}} = S_{\text{bulk}}^4 + S_{\text{bound}}^3.$$

For **single field** models

$$S_{\text{bulk}}^4 = \frac{1}{2} \int d^4x \sqrt{-g} [M_{\text{pl}}^2 R - 2P(X, \phi)]$$

$$S_{\text{bound.}}^3 = \frac{1}{2} \oint d^3x \kappa \phi^2 \Big|_{\eta_0} + \delta S^3$$

BEFT

The **idea**:

$$\delta S^3 \leftrightarrow |\Psi_0\rangle_{\text{non-BD}}$$

$$\delta S^3 \leftrightarrow \delta\kappa \quad \kappa + \delta\kappa \leftrightarrow \beta_k$$

Computing prim. 3p function

Need to consider:

1) 3pf from boundary: $\langle \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} \rangle_{\delta S^3} \neq 0$

2) 3pf from bulk: $\langle \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} \rangle_{\beta_k} \neq 0$

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BEFT

Using the **in-in** formalism

$$\langle \Psi(\eta) | \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} | \Psi(\eta) \rangle = -2\mathcal{R}e \left[i \int d\eta' \langle \Psi_0 | \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} H_I(\eta') | \Psi_0 \rangle \right]$$

where

$$H_I = H_I^{\text{bulk}} + H_I^{\text{bound.}}$$

$$H_I^{\text{bulk}} = - \int d^3x \delta \mathcal{L}^{\text{bulk}}$$

$$H_I^{\text{bound}} = - \int d^3x \delta \mathcal{L}^{\text{bound}} \delta(\eta - \eta_0)$$

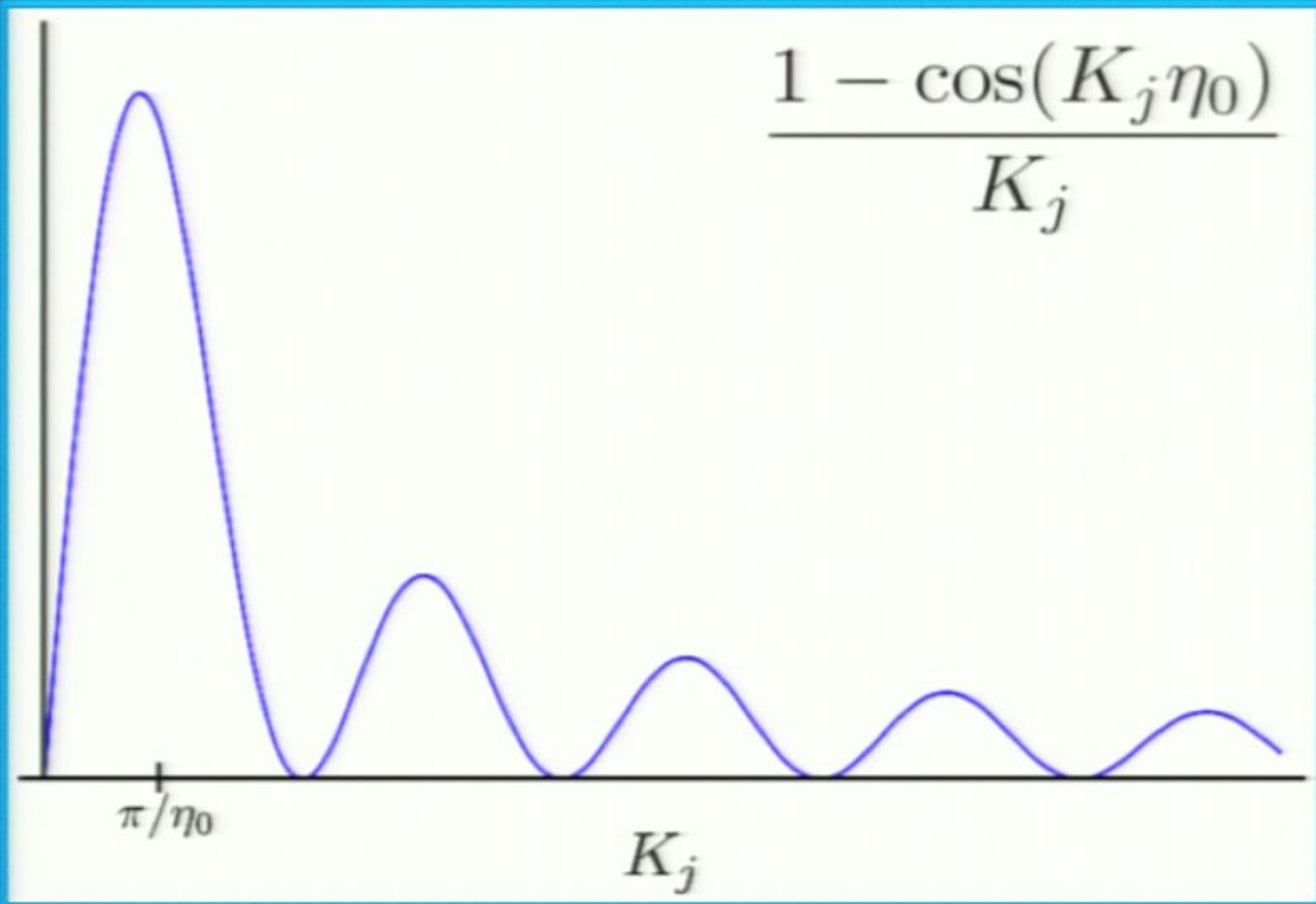
NON-GAUSSIANITIES

Contribution from Bulk (SFSR)

$$\Delta \langle \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} \rangle_{\beta_k \neq 0} = -(2\pi)^3 \delta^{(3)}(\sum_i \vec{k}_i) \frac{H^6}{\dot{\phi}^2} \frac{2}{\prod_i 2k_i^3} \sum_j \frac{k_1^2 k_2^2 k_3^2}{k_j^2 K_j} \beta_{k_j} (1 - e^{iK_j \eta_0}) +$$

With $K_j = k_1 + k_2 + k_3 - 2k_j$

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With $K_j = k_1 + k_2 + k_3 - 2k_j$

Max: $K_j = \pi/\eta_0 \sim 0 \rightarrow k_1 = k_2 + k_3$

$$\frac{\Delta \langle \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} \rangle_{\beta_k \neq 0}}{\langle \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} \rangle_{\beta_k = 0}} \propto \frac{\text{Re}[\beta_k] k_t \eta_0}{1 - \cos[k_t \eta_0]} \text{ENFOLDED!}$$

NON-GAUSSIANITIES

Contribution from Boundary (WIP):

$$\Delta \langle \zeta_{k_1} \zeta_{k_2} \zeta_{k_3} \rangle_{\text{bound}, \phi^3} = (2\pi)^3 \frac{H^3}{\dot{\phi}^3} \lambda \delta^{(3)}(\sum_i \vec{k}_i) \times \prod_i \frac{1}{k_i^3} \text{Im} \left(\prod_j (1 - ik_j \eta_0) e^{ik_j r} \right)$$

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Vanishes for modes $k \rightarrow \infty$, **working on details of what happens in between.**

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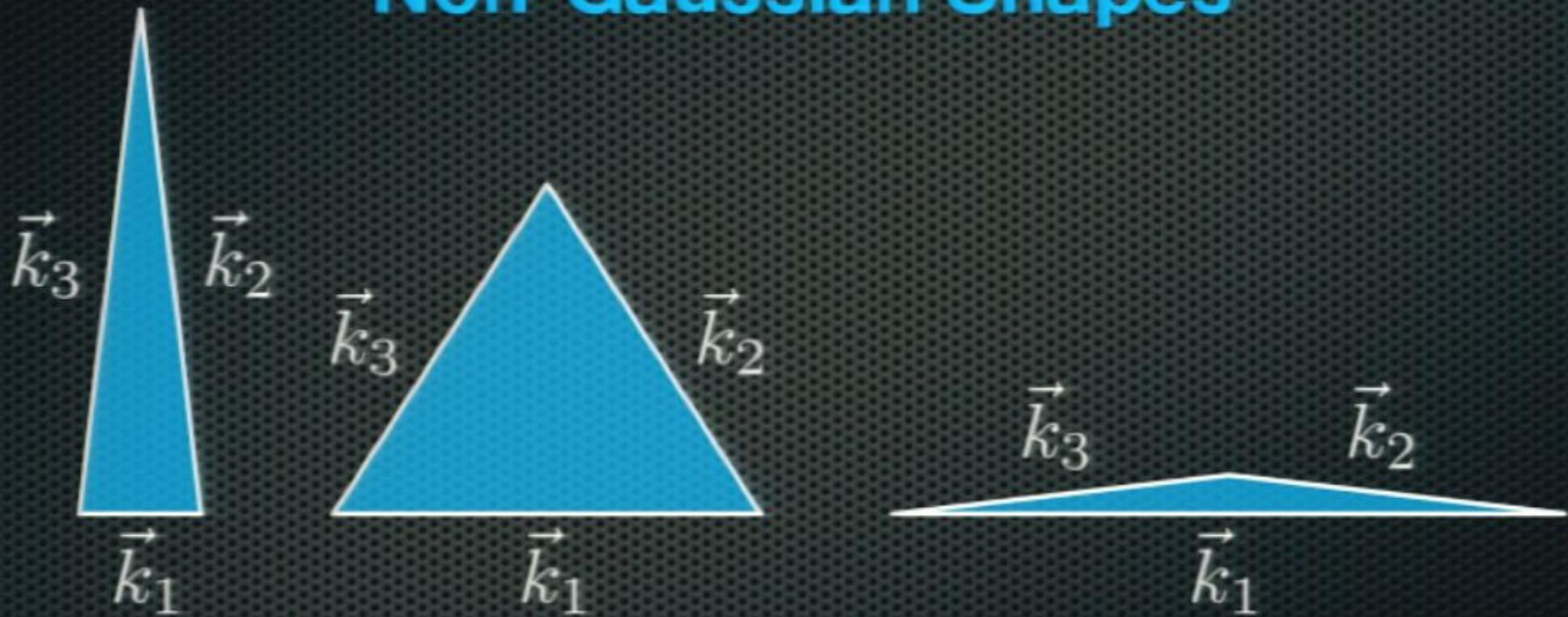
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LOCAL!

NON-GAUSSIAN SHAPES

Non-Gaussian Shapes



Local, Equilateral & Enfolded

NON-GAUSSIAN SHAPES



Factorizable **template**

$$F(k_1, k_2, k_3) = f_{NL}^{\text{enf}} 6 \Delta_\Phi^2 \left[\frac{1}{k_1^3 k_2^3} + 2 \text{ perm.} + \frac{4}{k_1^2 k_2^2 k_3^2} - \left(\frac{1}{k_1 k_2^2 k_3^3} + 5 \text{ perm.} \right) \right]$$

Take $F^{\text{equil}}(k_1, k_2, k_3)$ **and replace**
 $k \rightarrow -k$ **and demand** $F(k, k, k) \propto 6/k^6$

$$\frac{1}{(k_1 + k_2 + k_3)^3} \rightarrow \frac{1}{-k_1 + k_2 + k_3}$$

NON-GAUSSIAN SHAPES

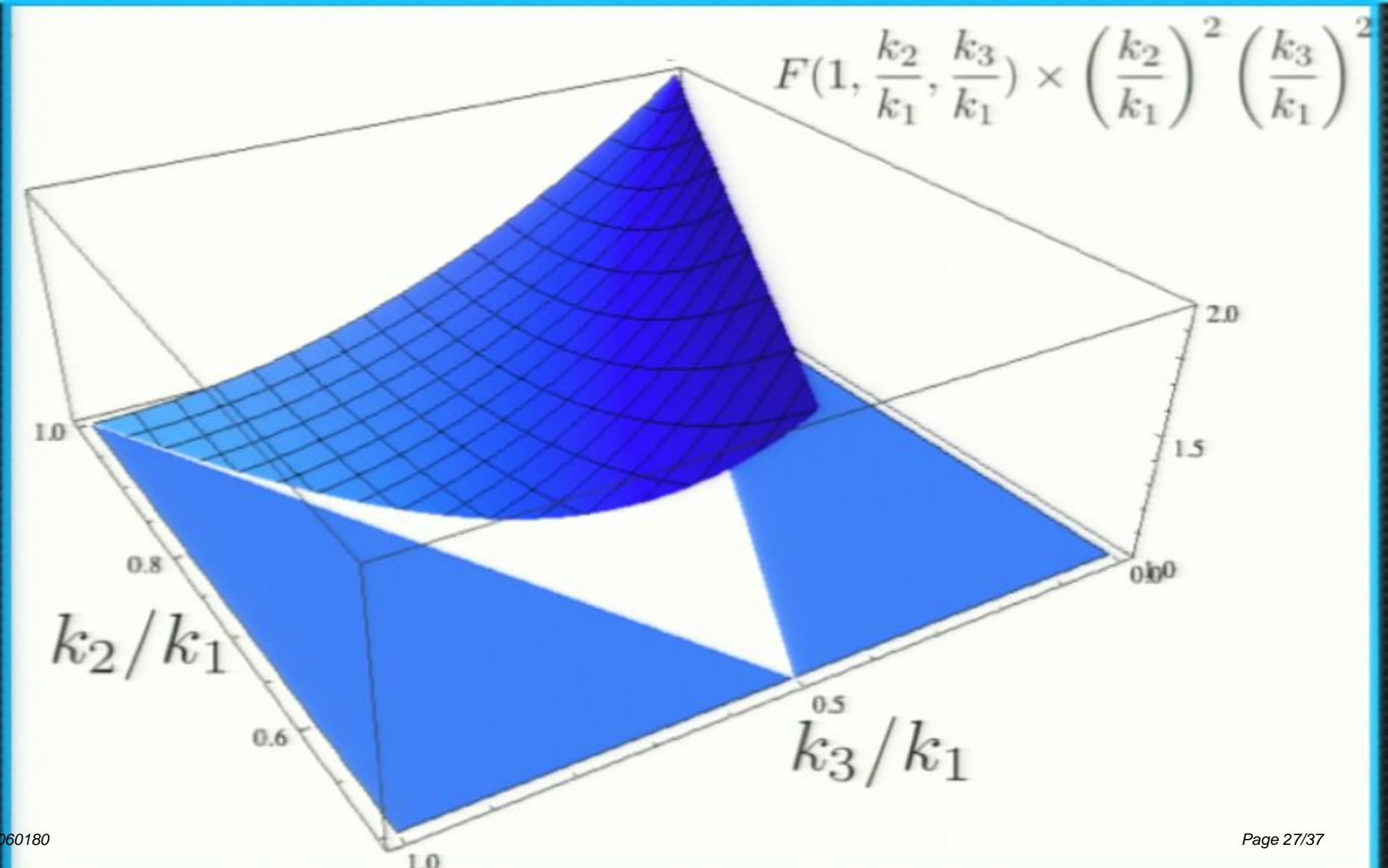


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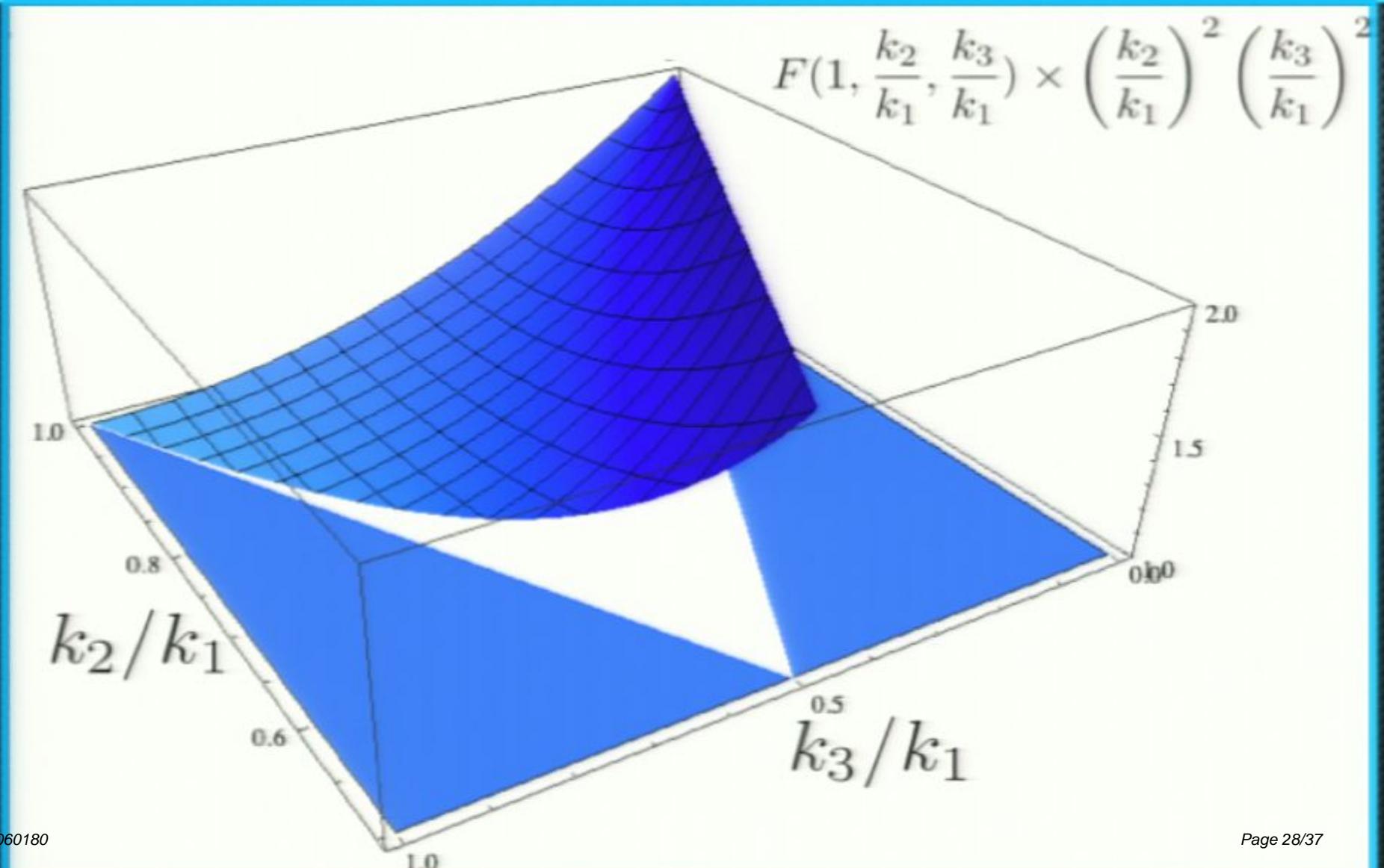
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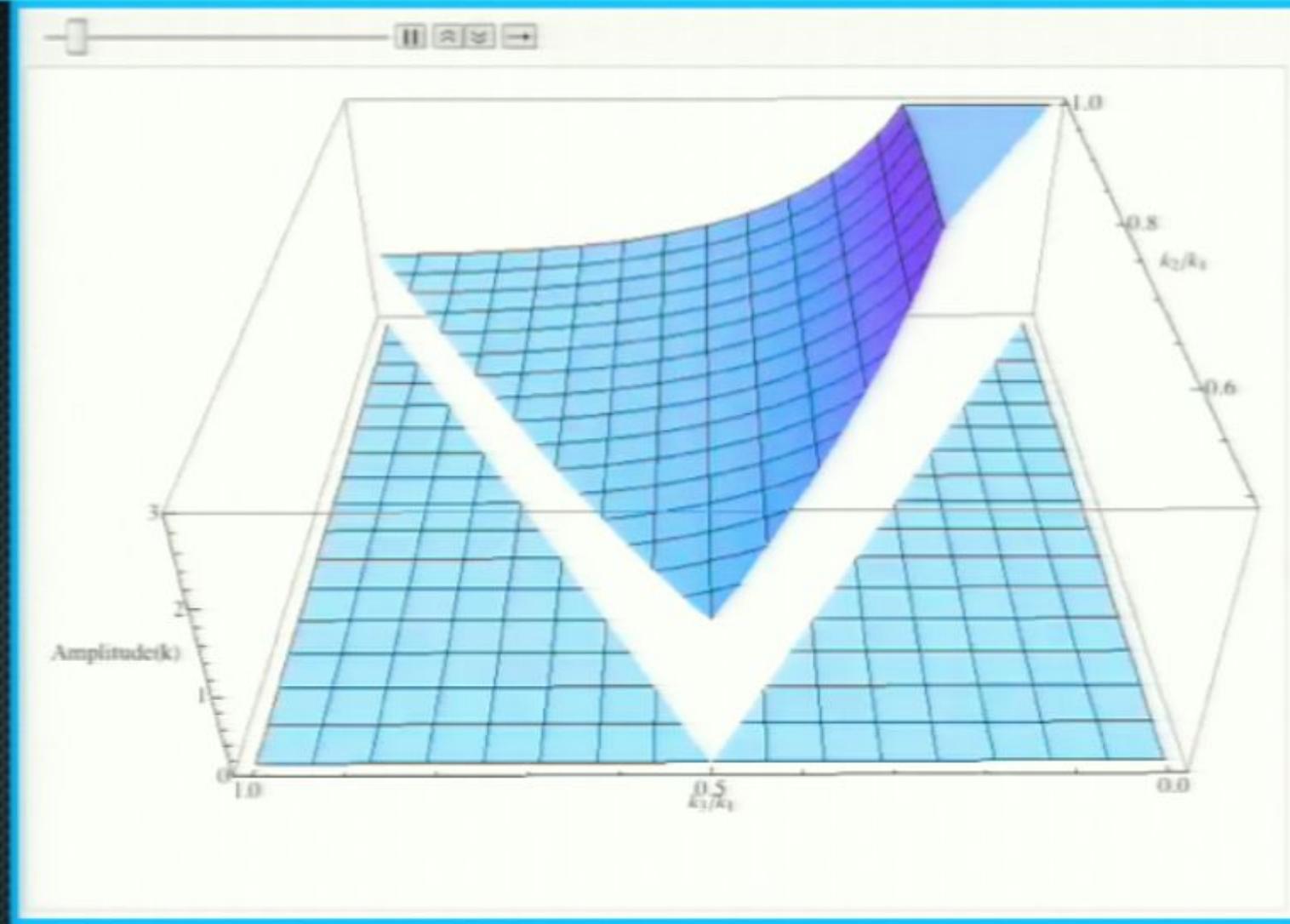
NON-GAUSSIAN SHAPES



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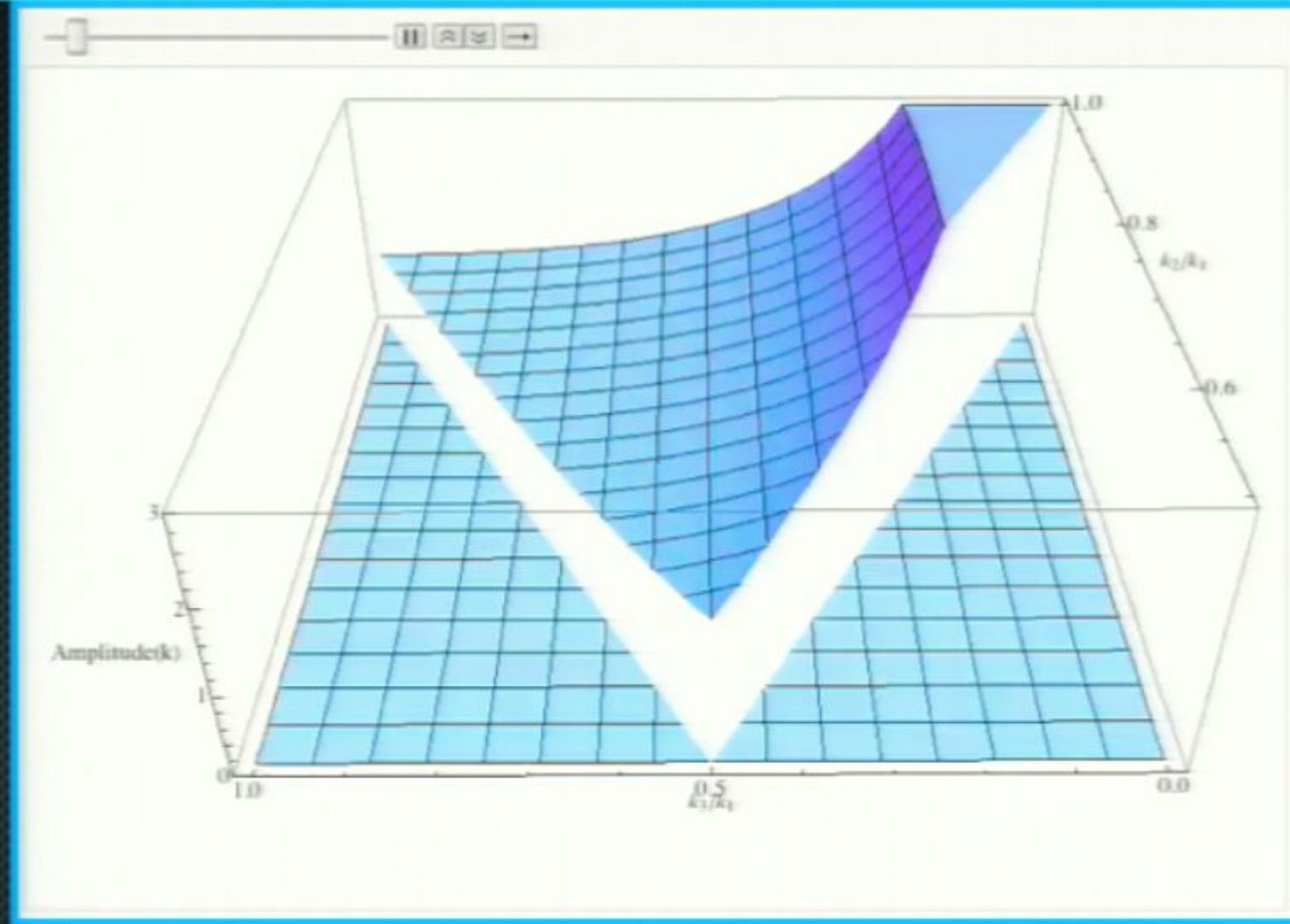
**Three templates, three extreme
Triangles:**

$$f_{NL}^{\text{loc}} \times A(k) \quad f_{NL}^{\text{loc}} \times B(k) \quad f_{NL}^{\text{enf}} \times C(k)$$

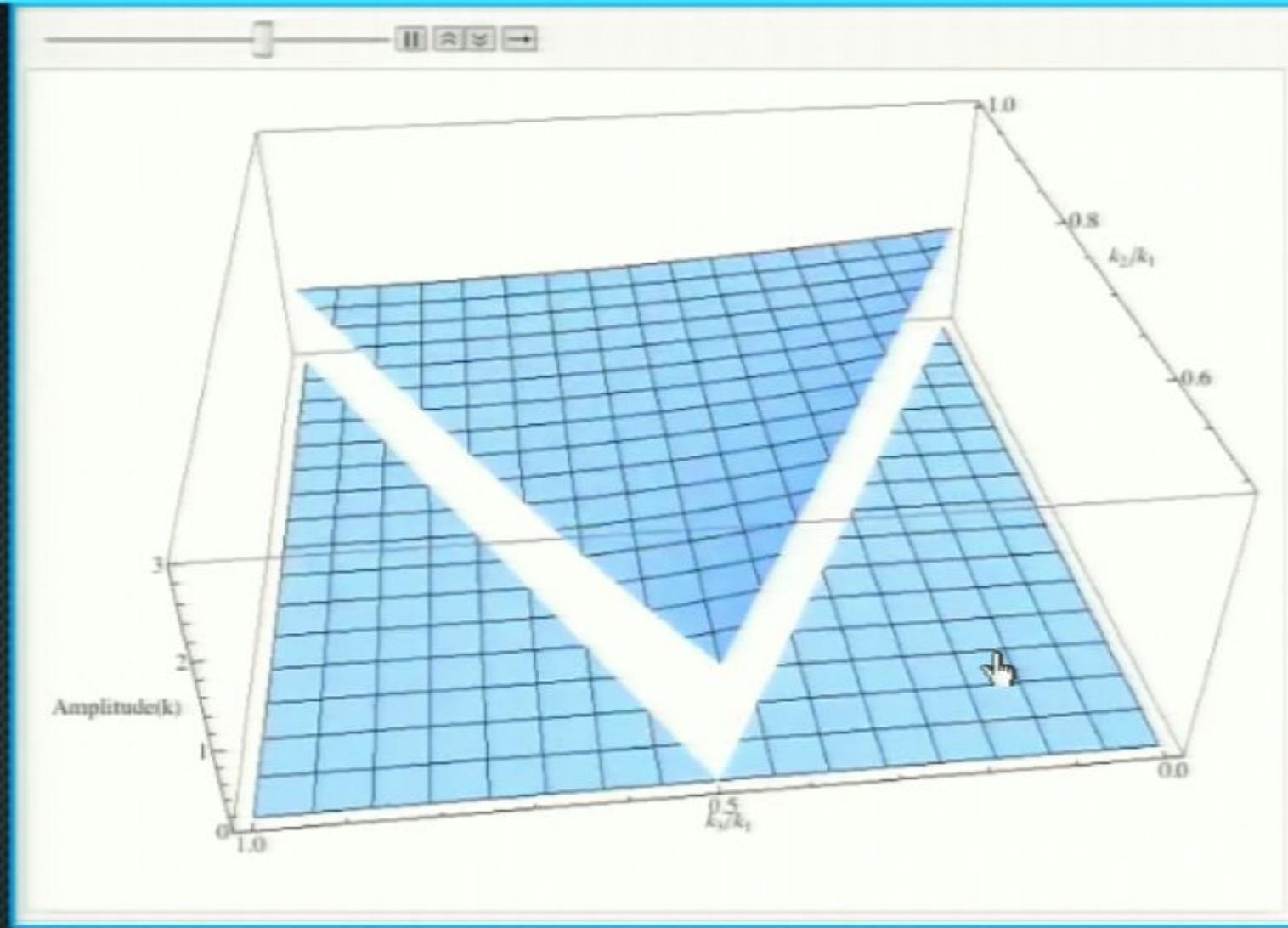
**Last triangle seem to be unique for
Initial state mod.**

**Equilateral and local shape alone
do not completely
parameterize a general 3p function**

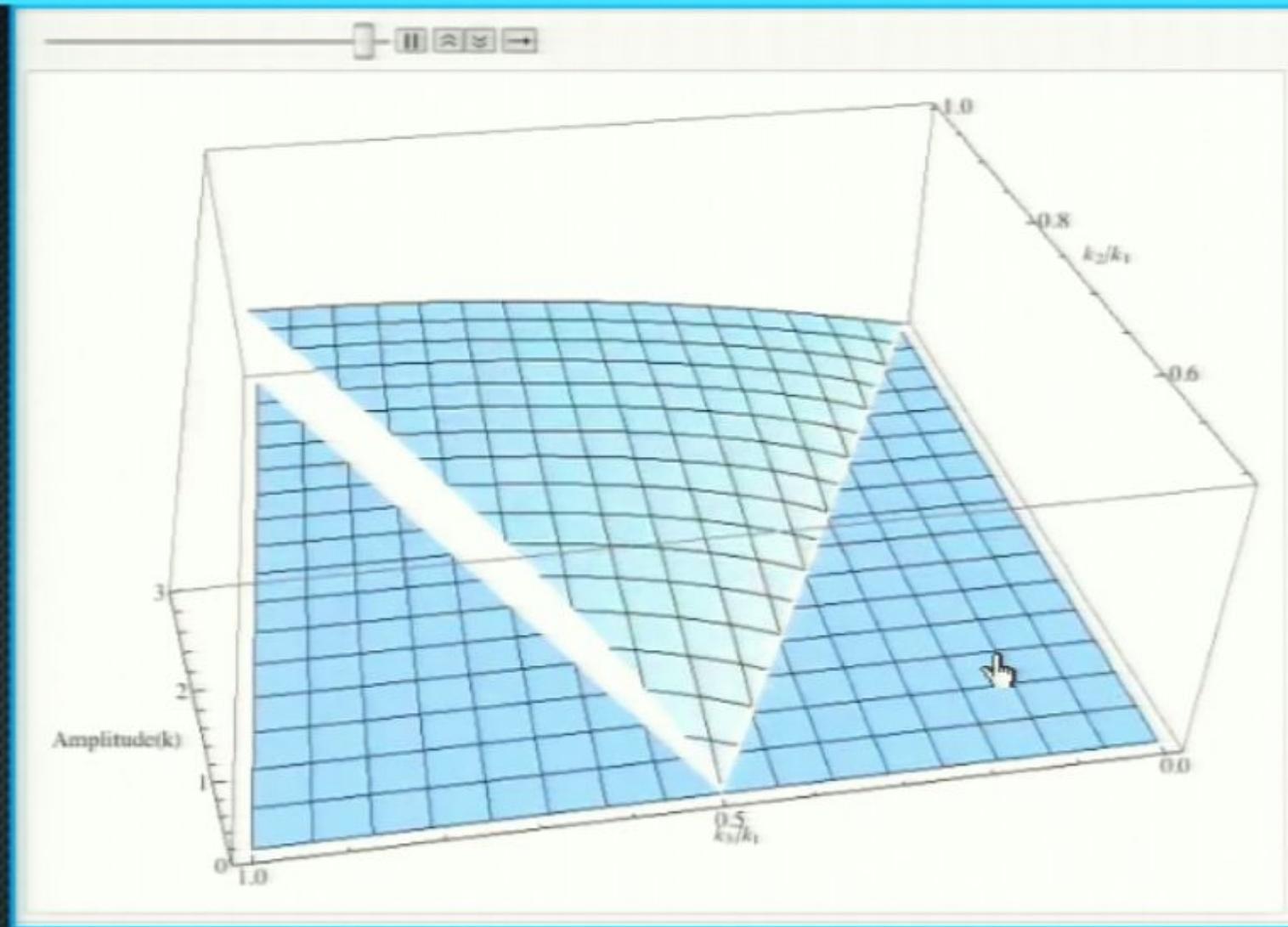
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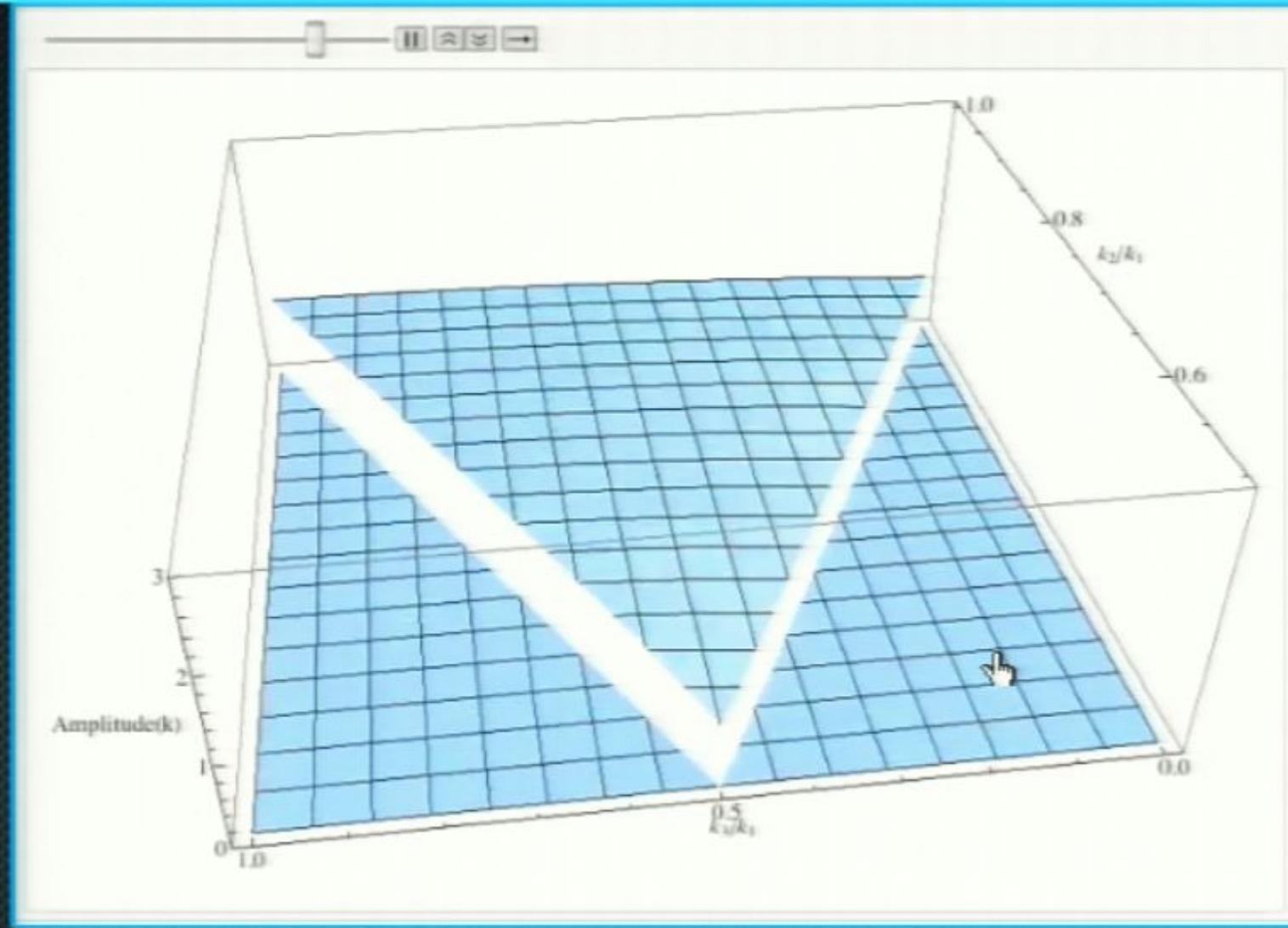
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NON-GAUSSIAN SHAPES

Example: ‘Flat shape’

$$\propto f_{NL}^{\text{flat}} \times \frac{1}{k_1^2 k_2^2 k_3^3}$$

Can be written as:

$$\propto \alpha f_{NL}^{\text{equil}} \times B(k) + \beta f_{NL}^{\text{enf}} \times C(k)$$

When this shape dominates data then:

$$f_{NL}^{\text{loc}} \simeq 0$$

$$f_{NL}^{\text{equil}} \simeq f_{NL}^{\text{enf}}$$

CONCLUSIONS

- ★ BEFT elegant approach to take *all* contributions due to initial state mod. in consideration
- ★ Non-Gaussianities coming from bulk and boundary differ: shapes, regime and likely amplitude (WIP)
- ★ Measure f_{NL}^{enf} using our template to constrain initial state