UV-completing Ghost Inflation

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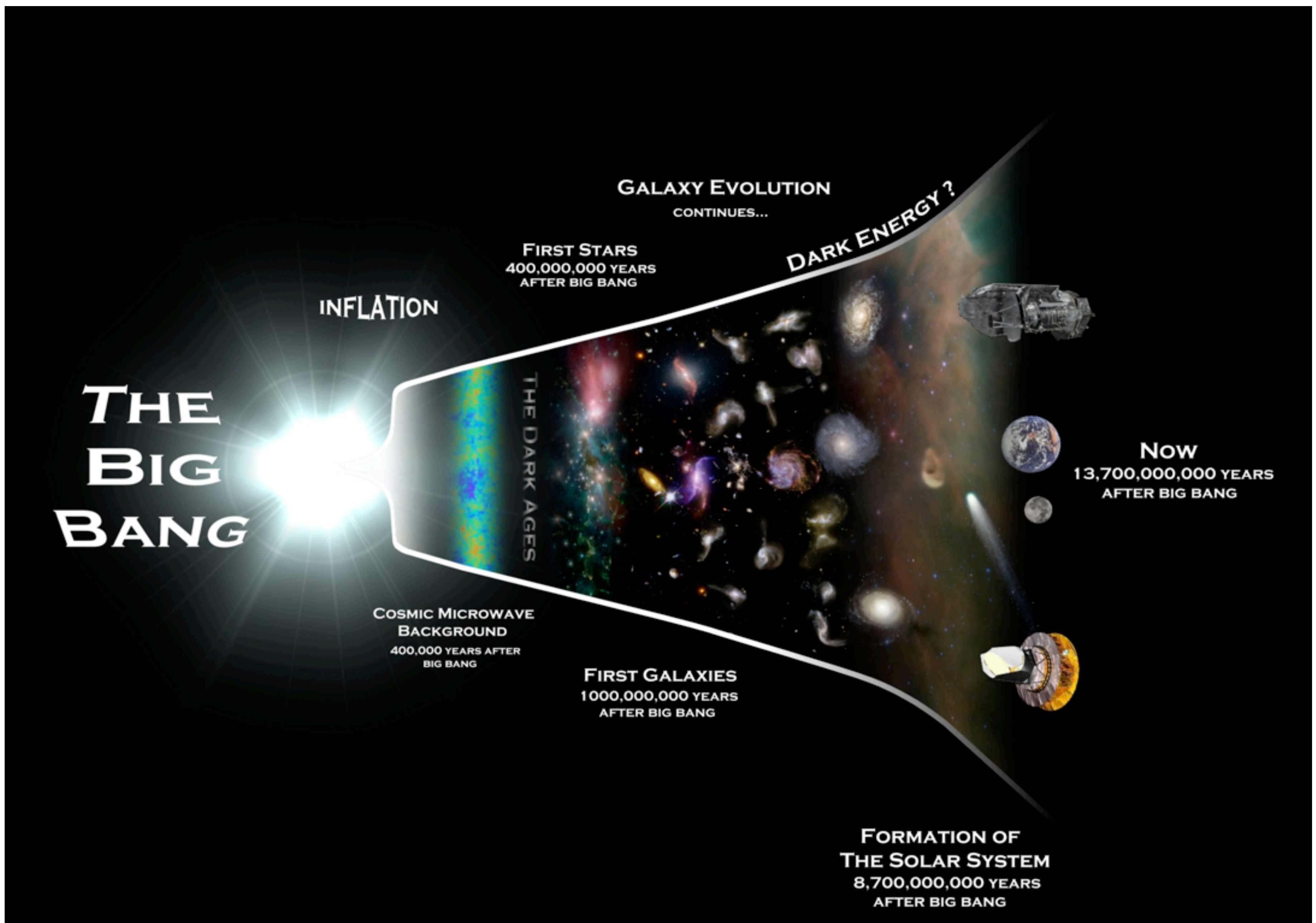
Galaxies, clusters etc. arose from quantum fluctuations amplified during Inflation

Inflation is a probe of the highest accessible energies (through cosmological observations)



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Enhanced

e.g. supersymmetry

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Different space-time symmetries:

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e.g. supersymmetry

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Reduced

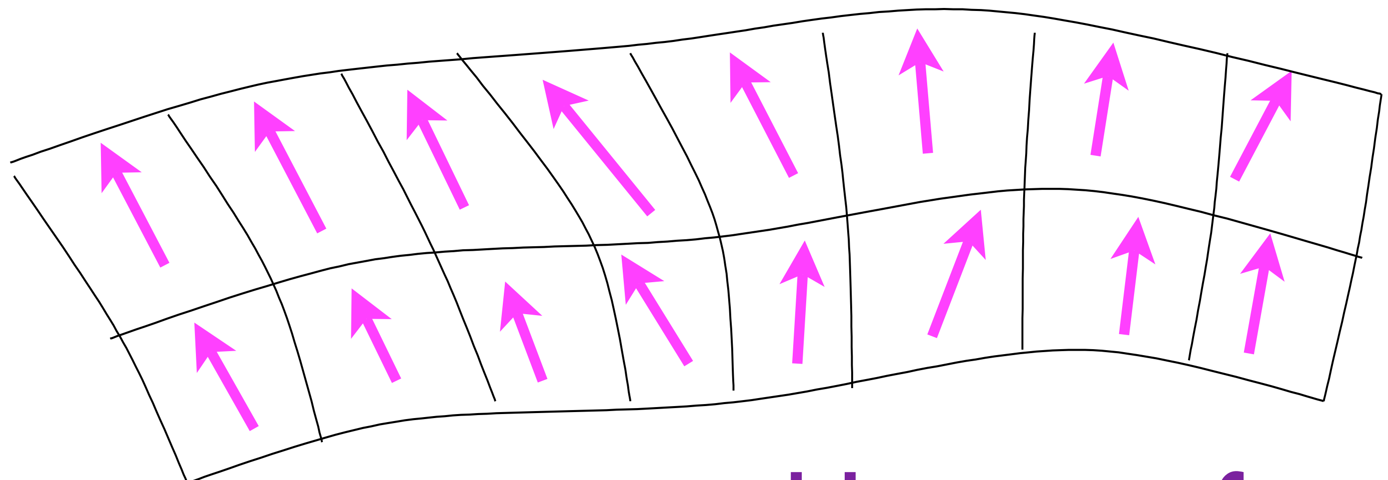
e.g. broken Lorentz Invariance

(c) P. Picasso

Breaking Lorentz Invariance

Space-time filled by a preferred **time** direction

Associated to a time-like unit vector u_μ



Generic aether:
Einstein-aether theory

$$u^\mu u_\mu = 1$$

Jacobson, Mattingly

Additional vectors!

Hypersurface orthogonal:
Khronon

$$u_\mu = \frac{\partial_\mu \varphi}{\sqrt{(\partial\varphi)^2}}$$

Blas, Pujolas, Sibiryakov

Gravity Lagrangian:

$$\mathcal{L}_{GR} + \mathcal{L}_u$$

$$\mathcal{L}_u \sim M_*^2 \ (\nabla u_\mu)^2$$

EFT up to M_*

Above can be embedded into Horava-Lifshitz gravity (only khronometric)

Inflaton with LV coupling

$$\mathcal{L}_I = \frac{1}{2}(\partial_\nu \theta)^2 - V(\theta) + \frac{\varkappa}{2}(u^\nu \partial_\nu \theta)^2 - \mu^2 u^\nu \partial_\nu \theta$$

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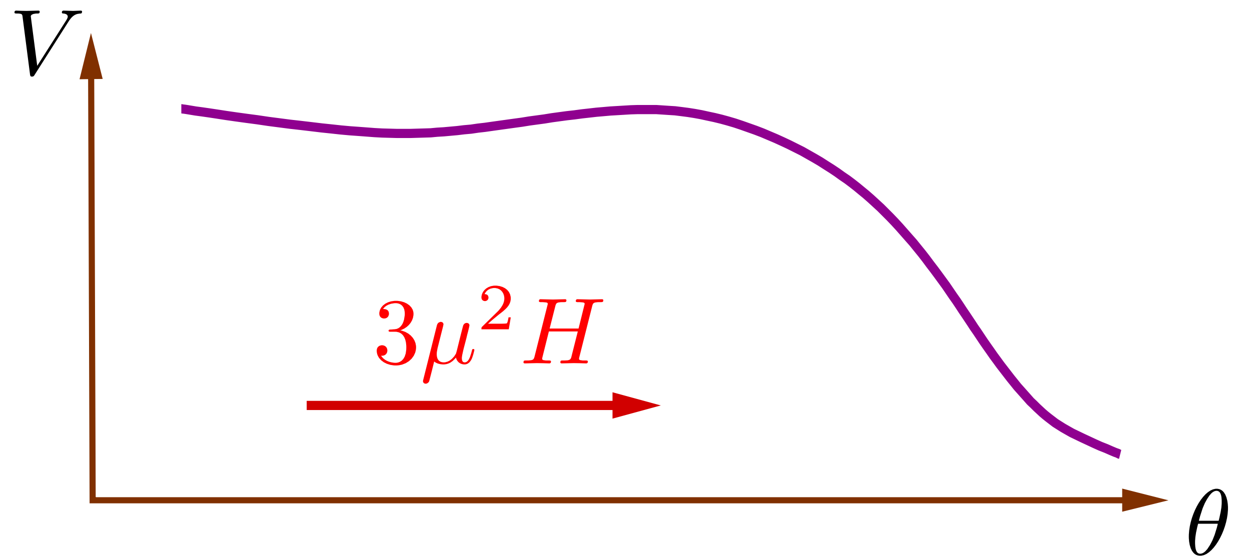
If $\varkappa = 0$ ➡ $\ddot{\theta} + 3H\dot{\theta} - 3H\mu^2 + V'(\theta) = 0$



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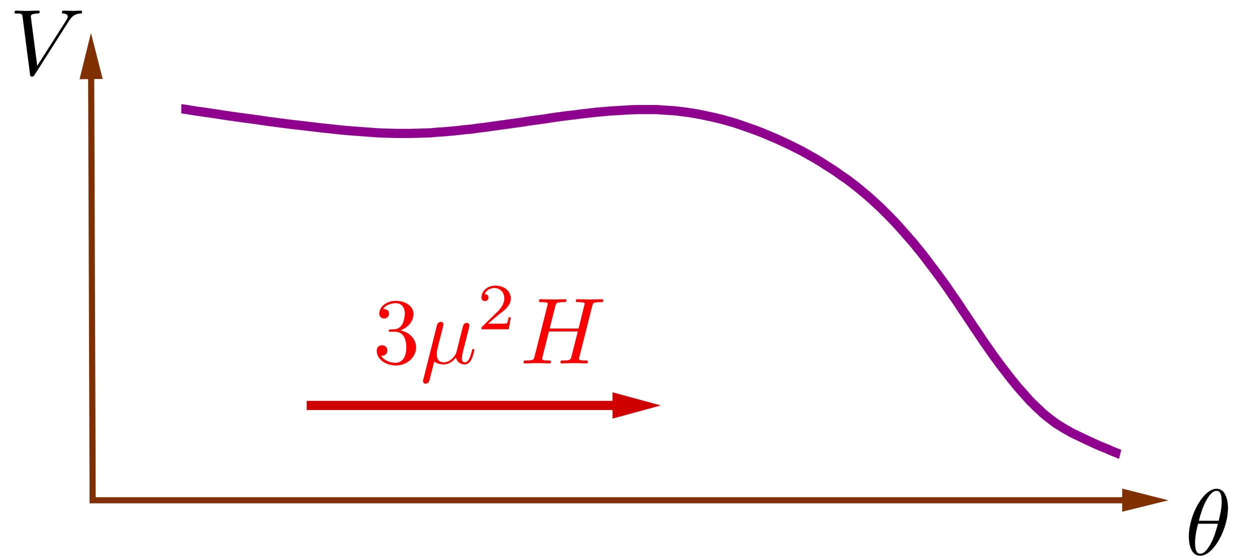

$V' \gg \mu^2 H$ ➡ small corrections to the slow-roll

Donnelly & Jacobson; Solomon & Barrow

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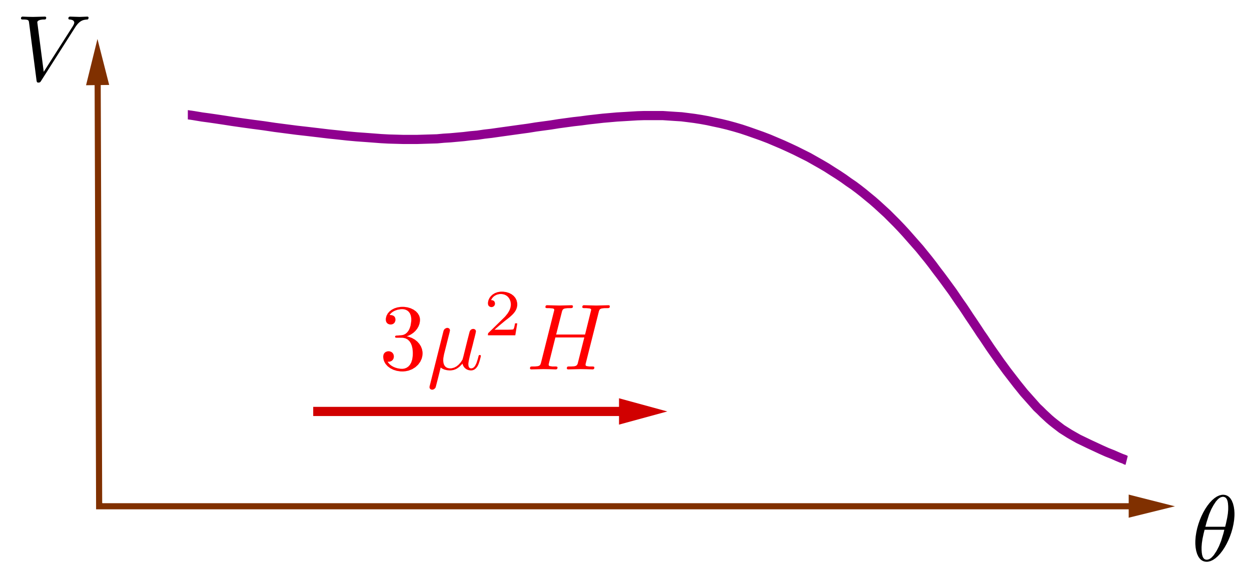

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$V' \ll \mu^2 H$ ➡ "fast-roll" $\dot\theta \approx \mu^2$

$H^2 = \frac{1}{3M_p^2}\left(\frac{\dot\theta^2}{2} + V\right)$ ➡ inflation occurs even for $V = 0$

Perturbations

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- tensors: standard
- vectors: absent or gapped
- scalars: $k > k_c$: two modes with linear dispersion $\omega \propto k$

  $k < k_c$: a single gappless d.o.f. $\omega^2 = \delta^2 k^2 + k^4/k_c^2$

$\delta^2 \sim -\frac{\dot{H}}{3H^2}$ $\qquad$ $k_c \sim \frac{\mu^2}{M_*}$

same as in (tilted) ghost inflation

Arkani-Hamed et.al.; Senatore

Relation with Ghost Inflation

GI (Arkani-Hamed et al. & Senatore):

1) EFT for perturbations only   cutoff k_c

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-) unable to capture the background evolution: problems with the end of inflation and reheating

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It's always nice to
UV-complete an EFT

L. Glashow A. Salam S. Weinberg

(UV-completing Fermi theory - Nobel prize'79)

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Our model:

1) EFT for both perturbations and background   cutoff M_*

(almost Planck scale!)

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Our model:

1) EFT for both perturbations and background — cutoff M_*

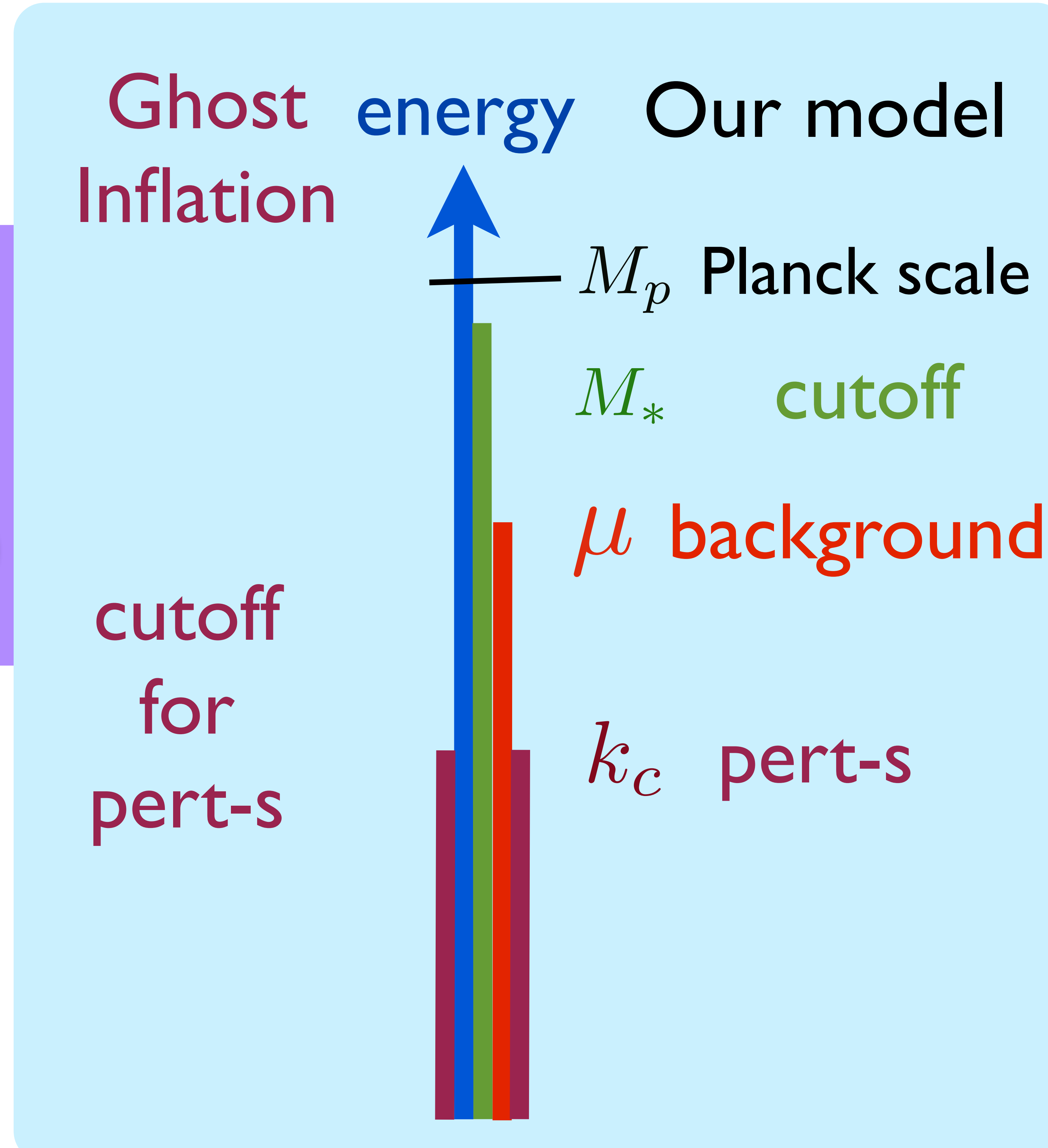
2) The same shape of non-Gaussianity — (almost Planck scale!)

3) May be totally UV-completed within Horava-Lifshitz-gravity

Relation with Ghost Inflation

UV-completion from k_c

to M_* (close to M_{Pl})



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$$r = 48\delta^3$$

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Disfavored by BICEP

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BICEP data: $r \sim 0.2$

$\Rightarrow$ $M_*/M_p \sim 0.05$

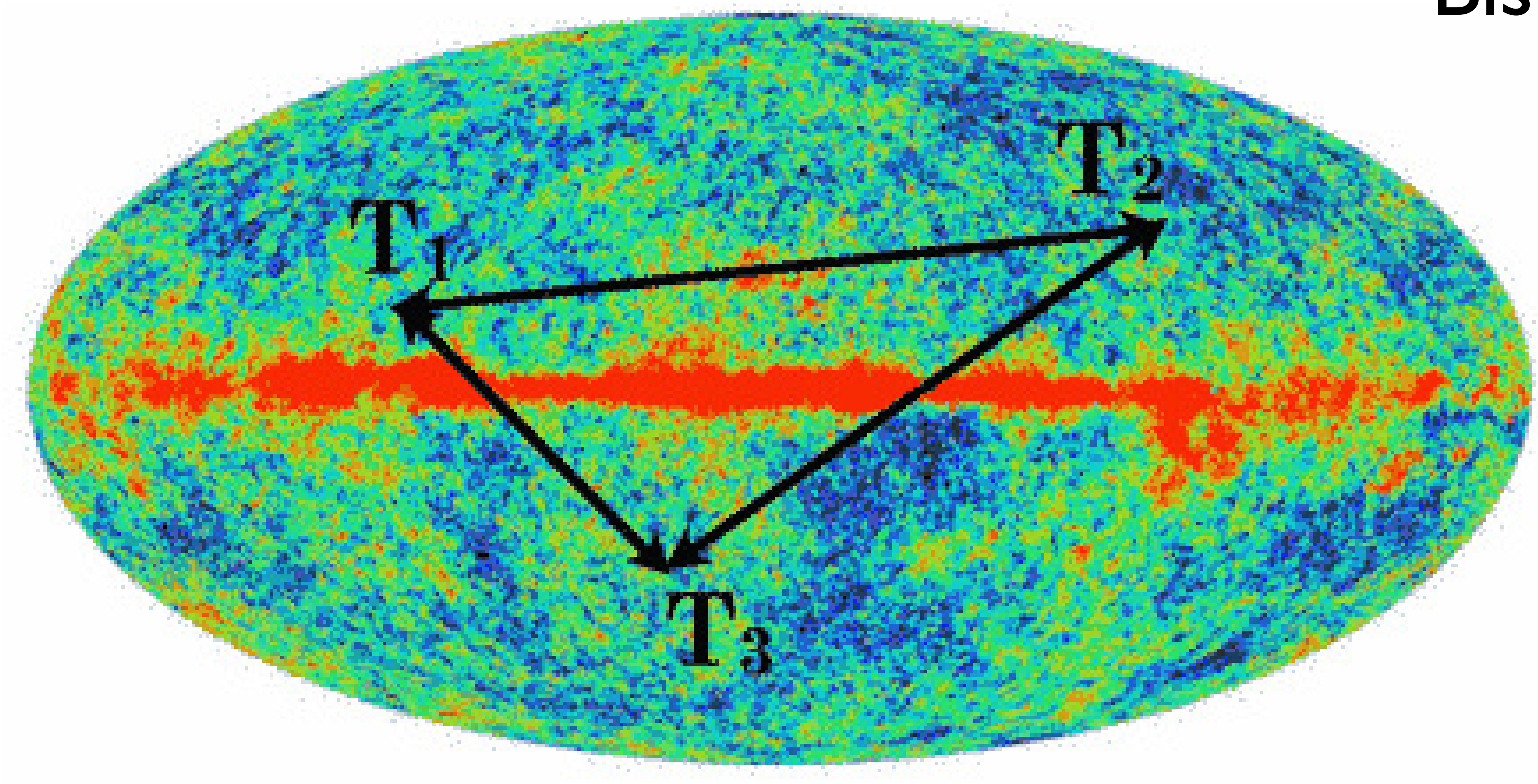
non - Gaussianity: definition

Newtonian potential

$$\langle\Phi(\vec{k_1})\Phi(\vec{k_2})\Phi(\vec{k_3})\rangle = (2\pi)^3\delta(\vec{k_1}+\vec{k_2}+\vec{k_3})B(1,\frac{k_2}{k_1},\frac{k_3}{k_1})/k_1^6$$

$$B(1,1,1) = 6(2\pi^2 P_\Phi)^2 f_{NL}$$

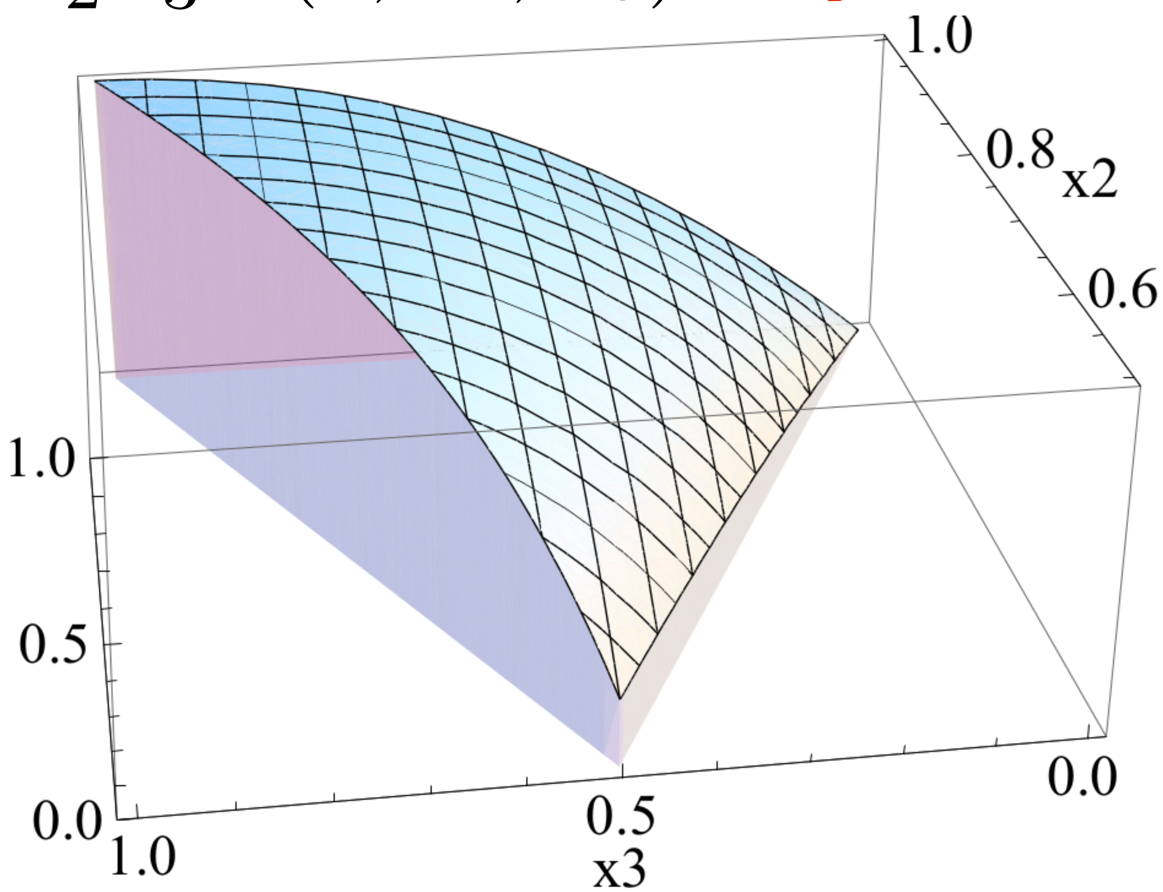
Bispectrum



non - Gaussianity: shape of bispectra

$$\omega^2 = \delta^2 k^2 + k^4/k_c^2$$

$x_2^2 x_3^2 B(1, x_2, x_3)$



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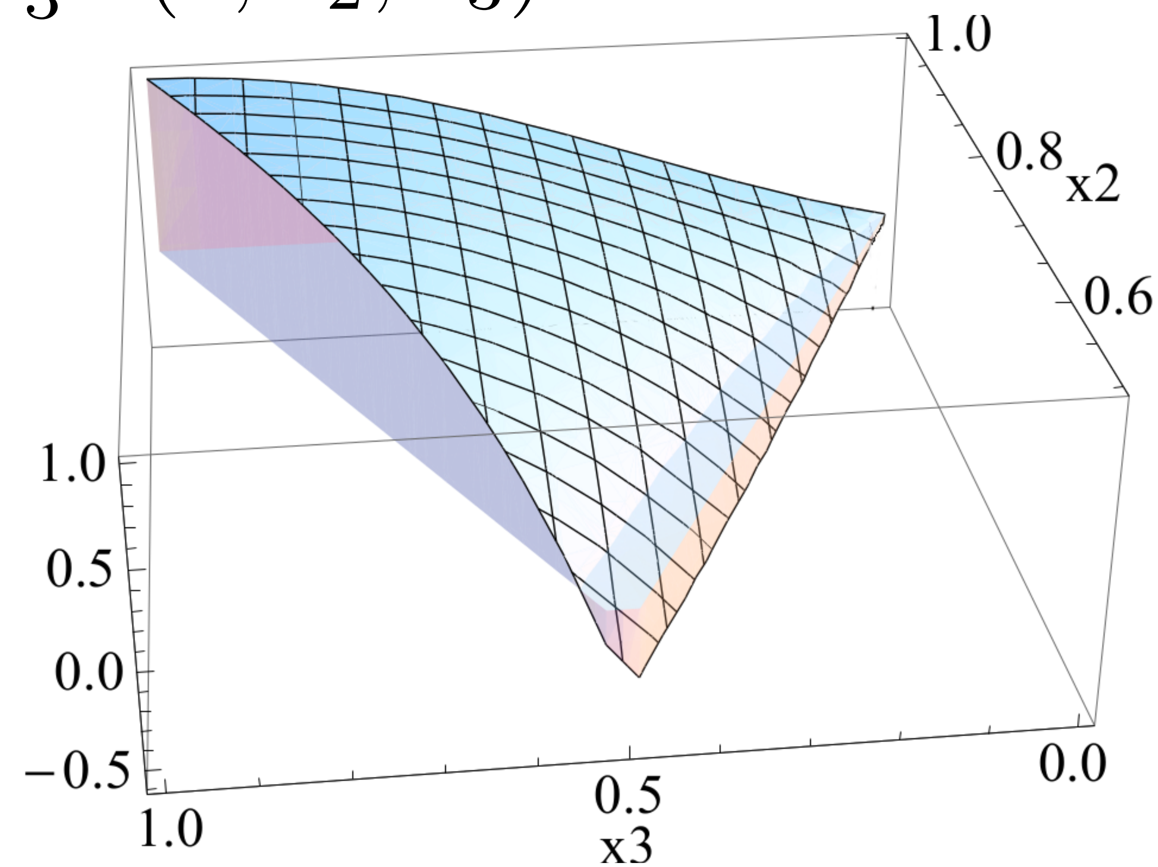


$$f_{NL} \sim -\frac{0.26}{\delta^2} \sim -40$$

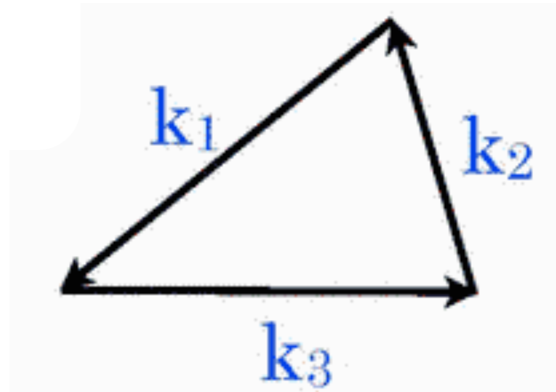
$$f_{NL} \sim -\frac{0.32 M_p}{M_*} \sim -5$$

cf. $f_{NL} = 8 \pm 73$ *Planck*

cf. $f_{NL} = -23 \pm 88$ *Planck*

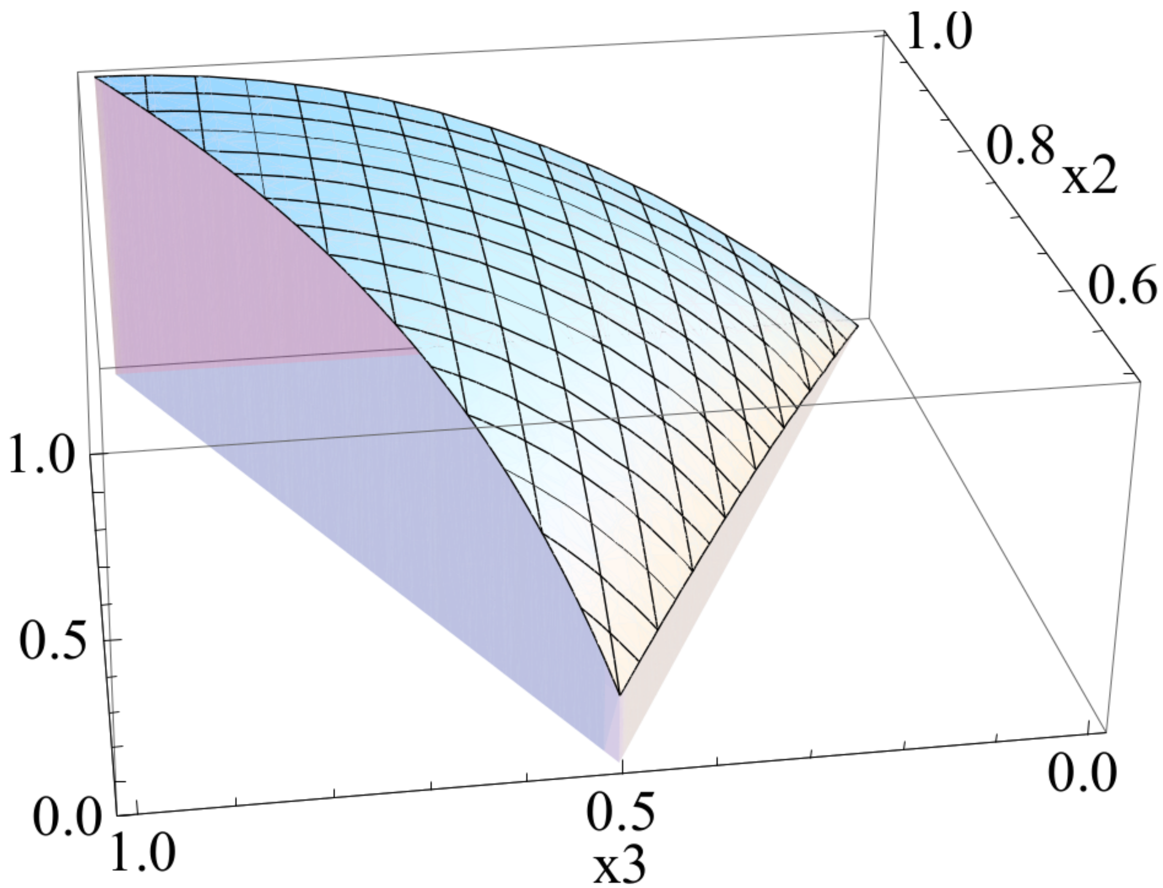
non

ectra



Saturated on the equilateral configuration

$$x_2^2 x_3^2 B(1, x_2, x_3)$$



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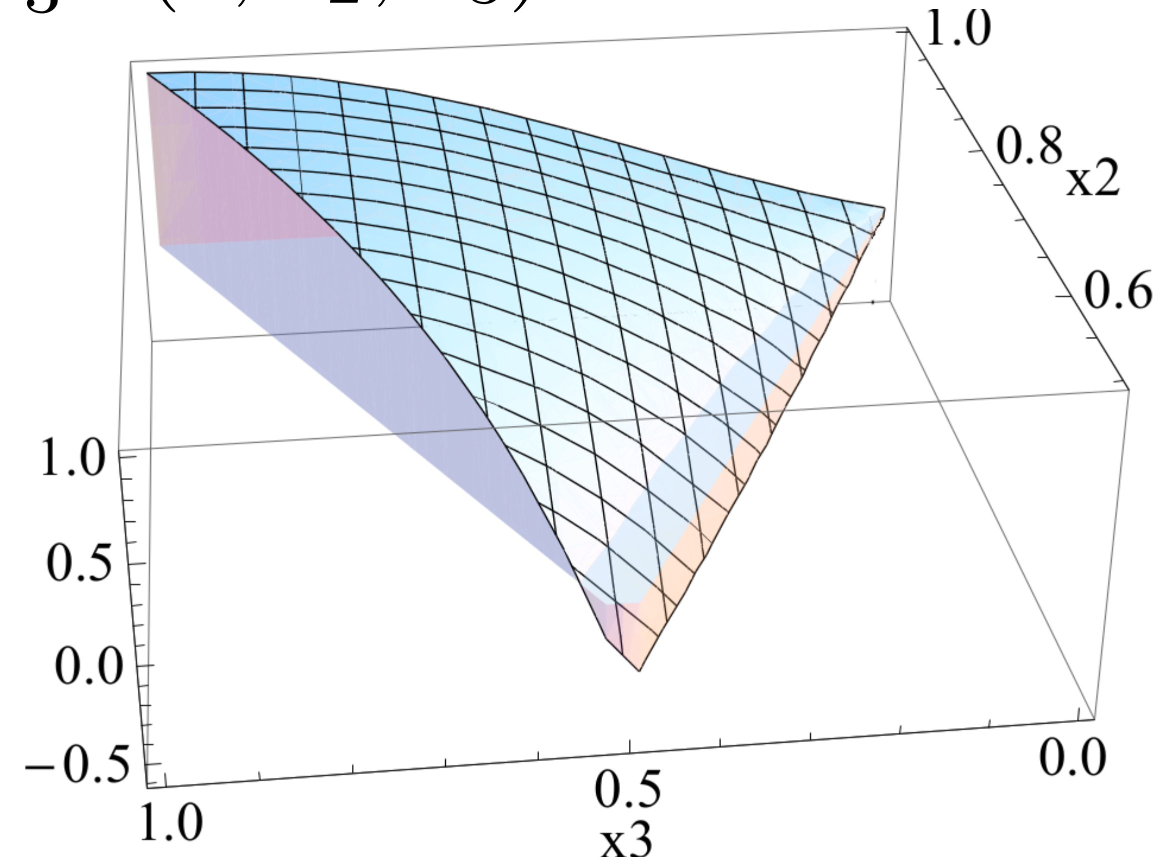

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Conclusions:

- Lorentz breaking in the inflaton sector:
  Fast-roll inflation even without any potential

- Perturbations = Ghost Inflation,
  UV-completion up the Planck scale

- Prediction for non-Gaussianity: equilateral type

  $f_{NL} \sim -5$

  Potentially accessible for future missions !

Outlook:

* Higher statistics (trispectrum related to bispectrum)
* UV - completing LV massive gravity (Dubovsky'04)

Thank you for your attention!

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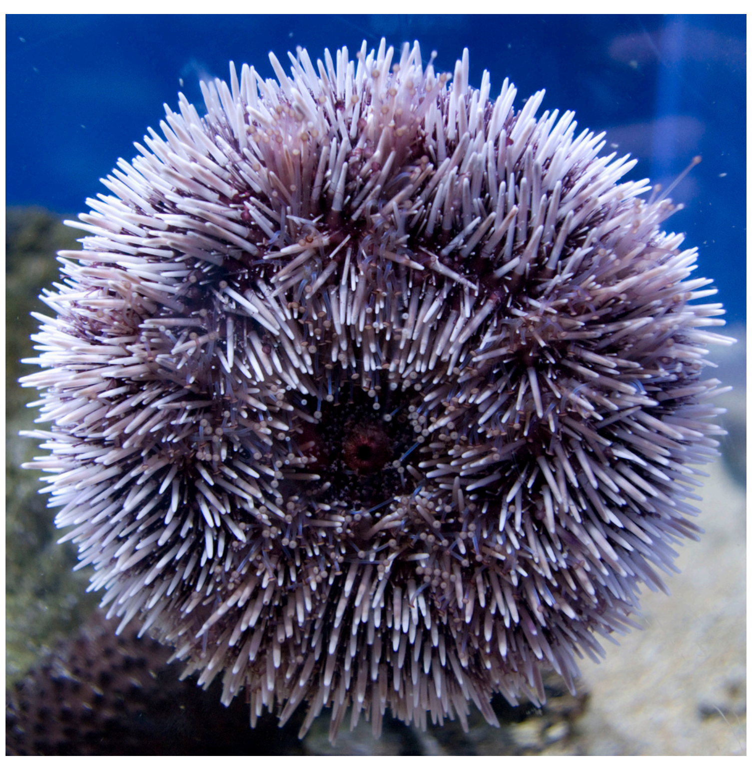
Enhanced

e.g. supersymmetry

sea hedgehogs



Echinoderm

Reduced

e.g. broken Lorentz Invariance

sea star

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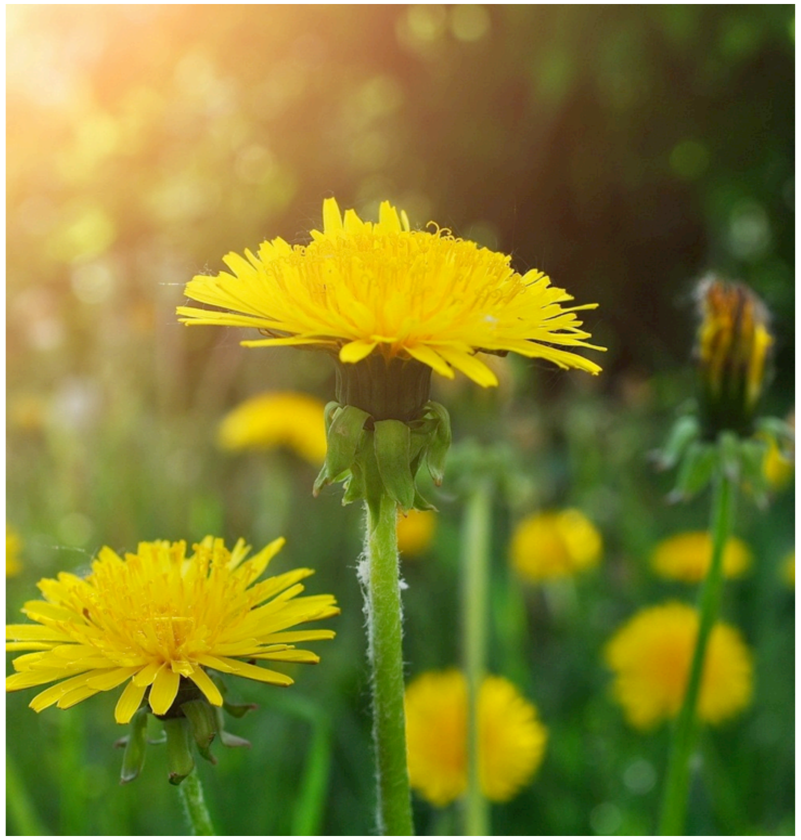

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