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Early universe cosmology in internal relativity

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■ Two views of special relativity

Einstein vs. Lorentz/Bell

- Background $\eta_{\mu\nu}$
- Matter **conforms** to background

- Matter **defines** geometry

matter *on* geometry vs. geometry *from* matter

■ A comparison

Lorentz, Bell, ... :

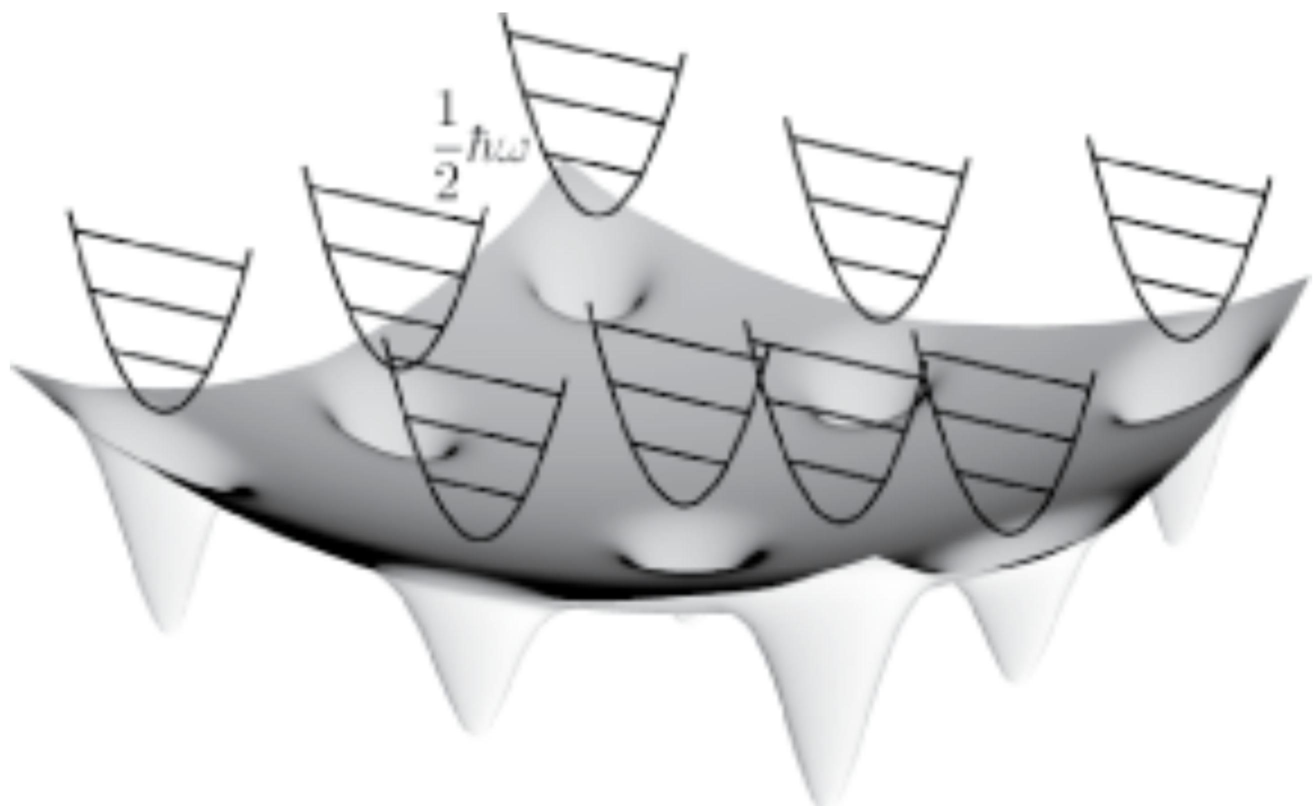
The physics of the system determines
the symmetries of the system

Einstein:

The symmetries of the system
are fixed by the background

Goal: Do for GR what Lorentz & Bell did
for special relativity.

▪ cosmological constant



no matter on geometry

$$\Longrightarrow$$

cosmological constant problem changes

od, hep-th/0409048

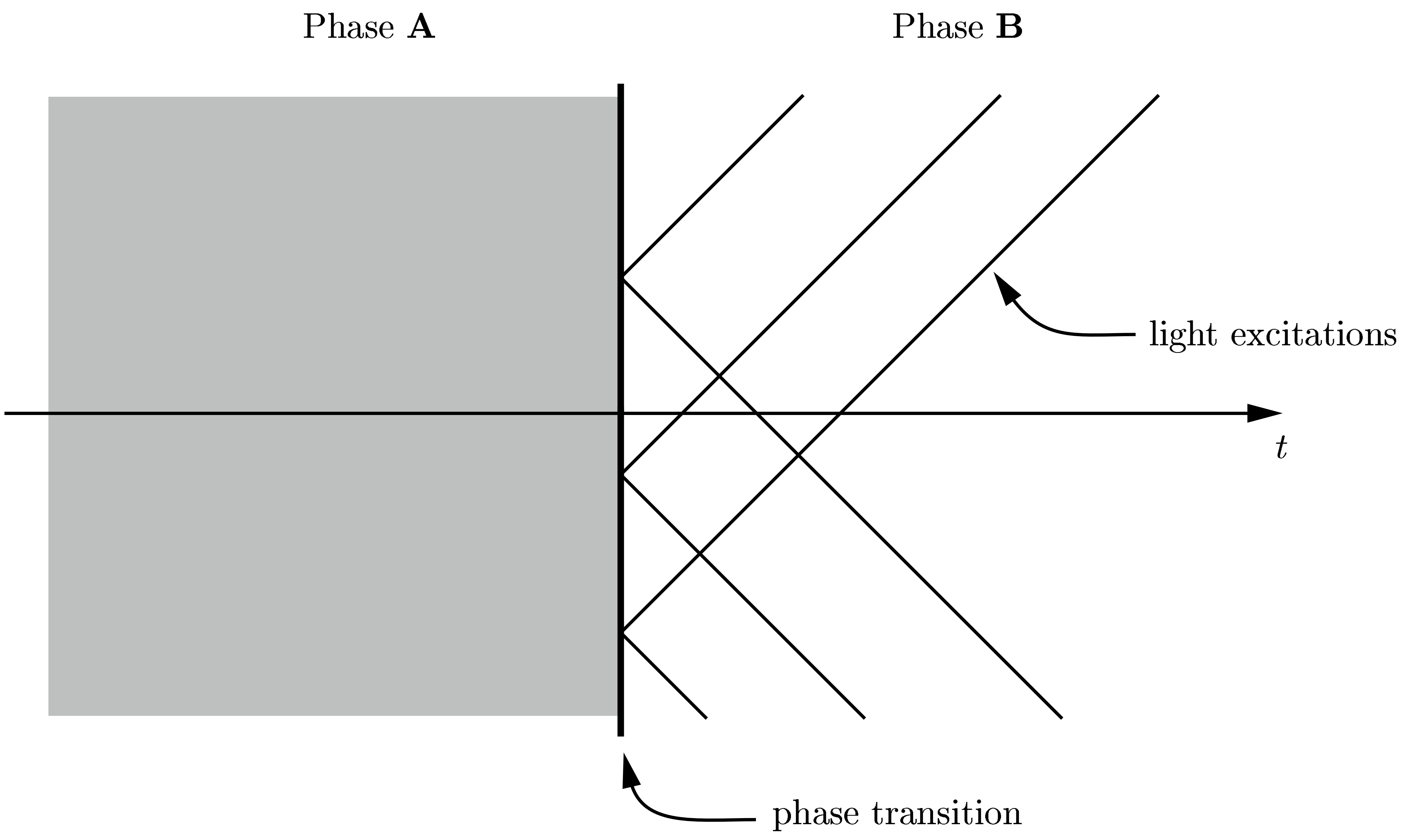
■ A possibility: the emergence of spacetime

- Geometry defined by matter
- Matter can emerge in a phase transition

→ **Geometry can emerge in a phase transition***

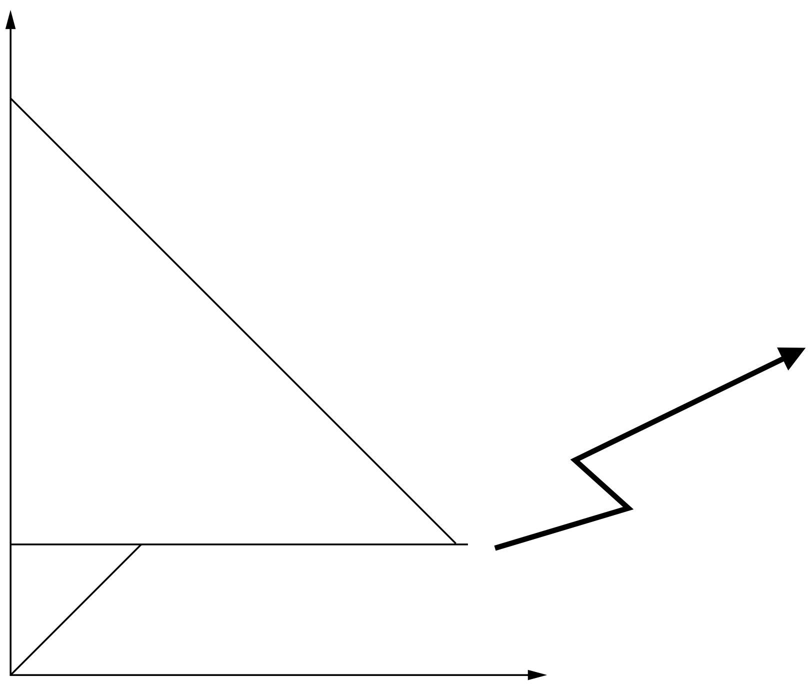
*not possible using the Einstein point of view because spacetime is a priori

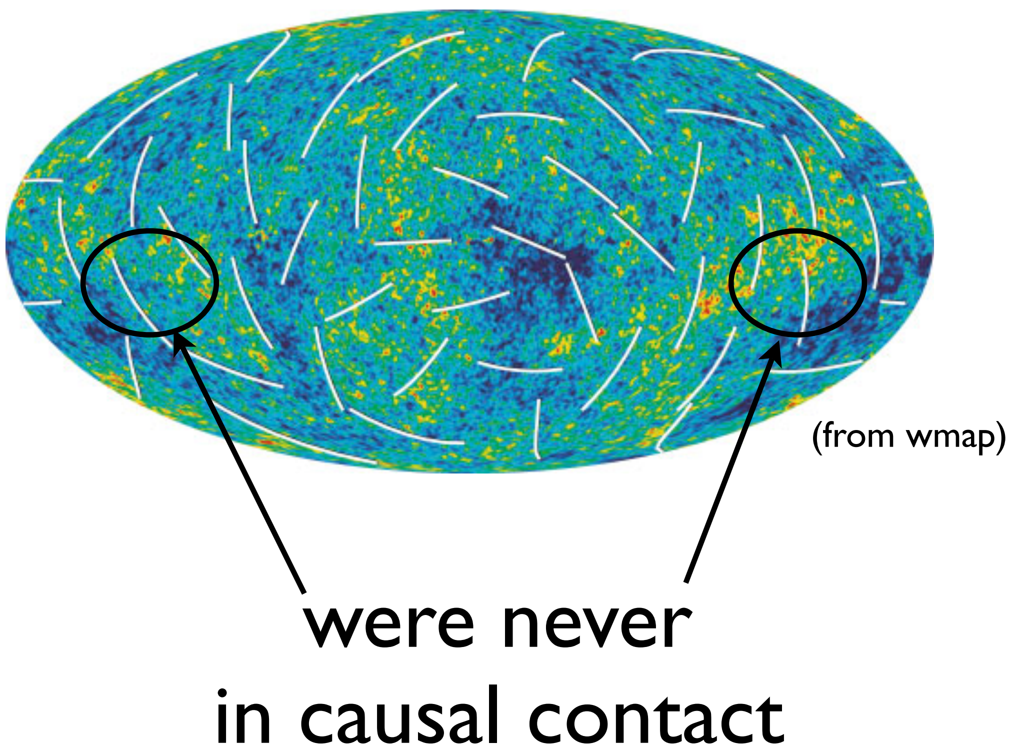
■ The emergence of spacetime



■ Interest for cosmology

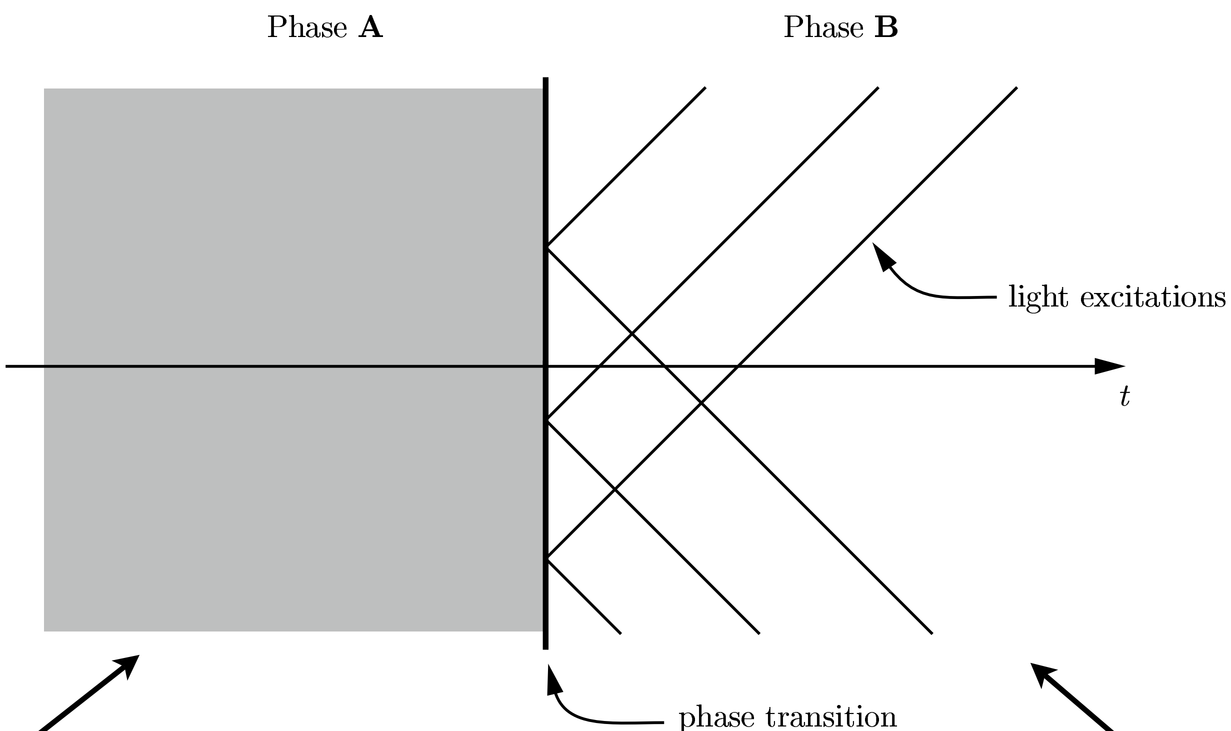
horizon problem:





• horizon problem can be seen as a consequence of applying our notion of causality where it does not apply anymore.

■ Addressing the horizon problem



different causality

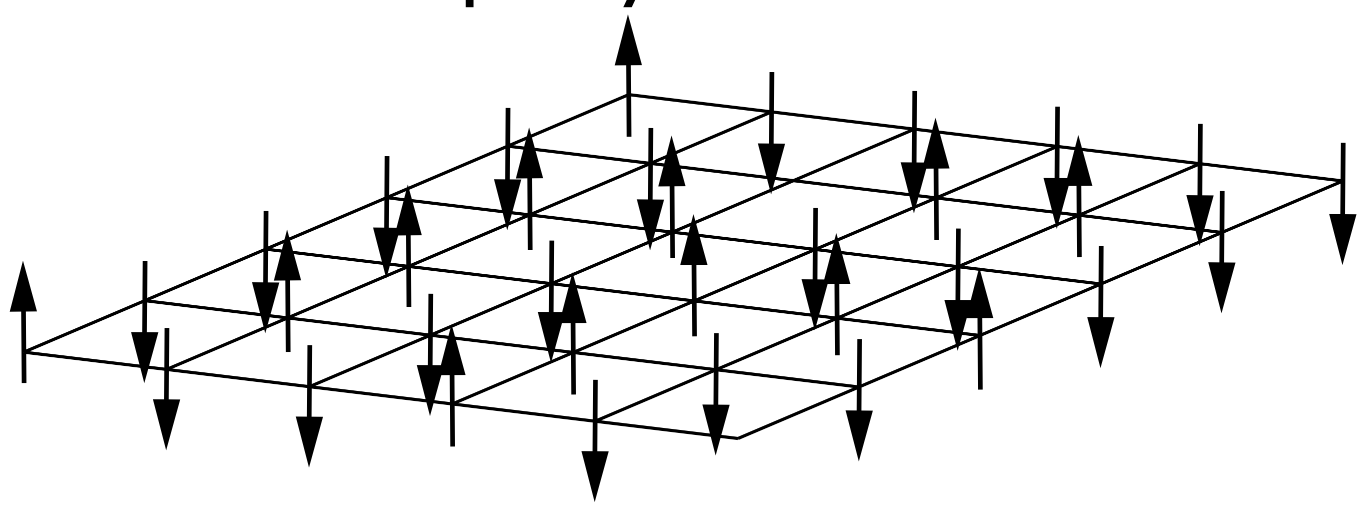
our causality

Horizon problem does not arise

Question: Do we get the right spectrum?
Does this provide an alternative to inflation?

■ Setup

three dimensional spin systems on a lattice



examples:

(i) Ising model (+ modifications)

(ii) stringnet condensates (a la Wen)

Assume a ground state with order parameter

$$\theta_0$$

■ Perturbations in Internal Relativity

Want to calculate:

$$\delta_\Phi^2(k)$$

In internal relativity we have:

$$\theta \simeq \Phi$$

$$ds^2 = (1+\theta)dt^2 - (1-\theta)\delta_{ij}dx^i dx^j$$

$\theta \simeq \Phi$

We thus need to calculate:

$$\delta_\theta^2(k)$$

■ The spectrum

$$\delta^2_\Phi(k) \simeq \delta^2_\theta(k) \qquad \text{(internal relativity)}$$

$$\simeq k^3\, G(k) \qquad \text{(theorem)}$$

$$\simeq k^3\, \frac{1}{k^3} \qquad \text{(fourier transform)}$$

$$= \text{const.}$$

i.e. the spectrum is scale free

The tilt

For a real phase transition we have:

$$G(x) = \frac{e^{-|x|/\xi}}{|x|^{d-2+\eta}}$$

critical exponent

dynamical process

$$G(x) = |x|^{\eta}$$

System	η
Mean-field	0
3D theory	
n=1 (Ising)	0.04
n=2 (xy-model)	0.04
n=3 (Heisenberg)	0.04
Experiment	
3D n=1	0.03 – 0.06

then:

- no slow-roll parameters needed
- discreetness of nature

■ Cosmology

- New/old look at special relativity allows for the emergence of spacetime.

- Phase transition in the early universe can produce a flat spectrum of scalar perturbations.

- Tilt of the spectrum might be a consequence of a fundamental discreteness in nature.