# Effets quantiques dans des champs gravitationnels forts.

Julien Serreau (A.P.C.)

- R. Parentani (LPT, Orsay)
- F. Gautier (T.U.M, München)
- M. Guilleux (APC)

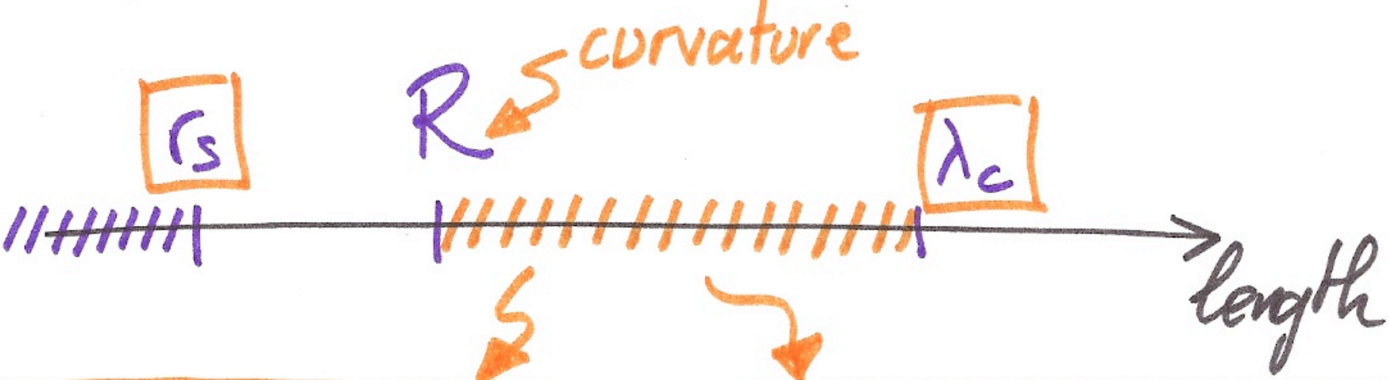
# QUANTUM PHYSICS & GRAVITATION

## VII ⇒ Quantum gravity : ?

distances $\lesssim$ $\lambda_c = \frac{\hbar}{mc}$ ; $r_s = \frac{Gm}{c^2}$

(Compton wavelength) (Schwarzchild radius)

## VIII ⇒ Quantum dynamics in classical gravitational fields




| Unruh-Hawking radiation from black holes | Amplification of density perturbations during inflation |
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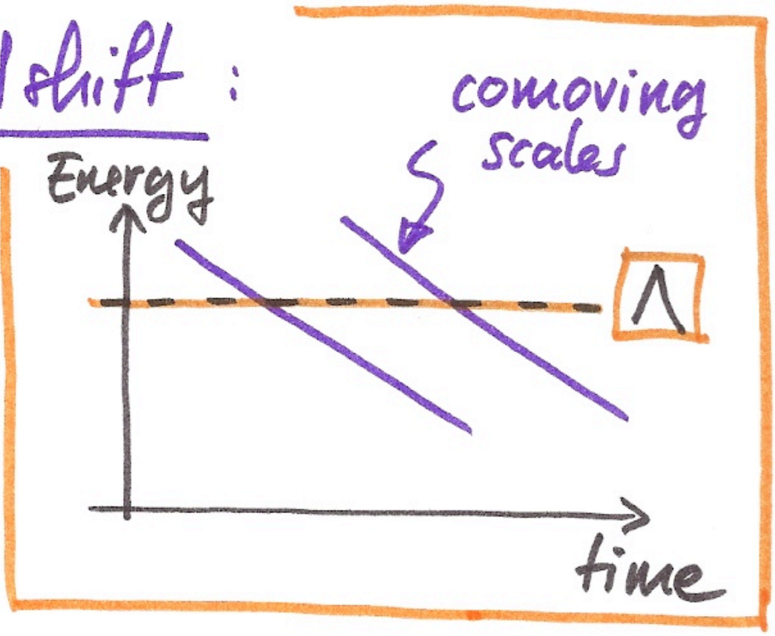
⇒ (Quantum) Particle production by gravitational field

# Gravitationally induced quantum effets

Specific effects ⇒ specific questions

## Gravitational redshift:




Trans-Planckian (decoupling) issue

→ Validity of effective theories (QFT in curved spacetimes)

## Gravitational particle production

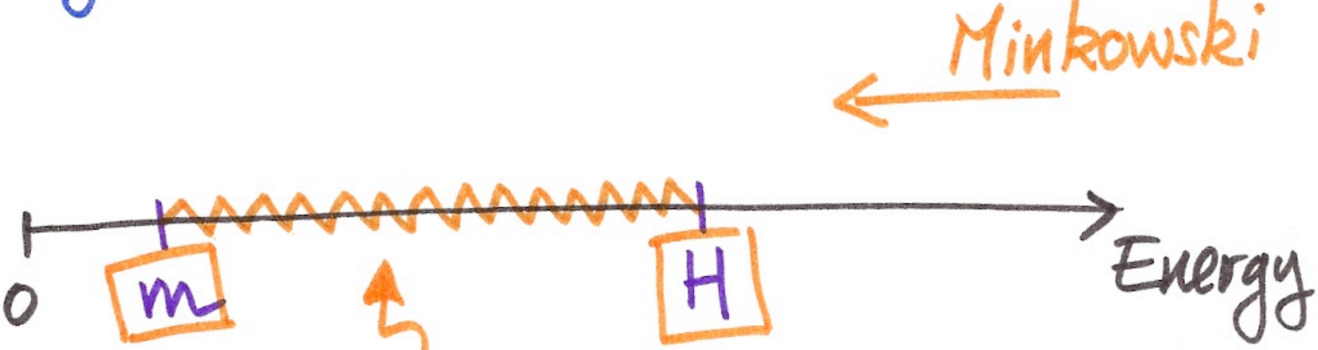
Infrared / secular effects

→ Understanding of genuine quantum (loop) corrections

## Foundations of QFT in curved spaces

# QFT in de Sitter spacetime

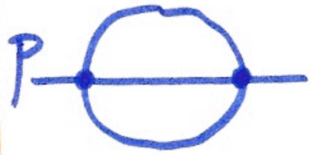
↳ quantum corrections to inflationary dynamics and observables.




**Specific, gravitationally induced effects**

⇛ The perturbative series (loops) is plagued by infrared/secular divergences

<u>example</u> "$\lambda\varphi^4$"-theory

 $\sim \dfrac{\lambda H^4}{m^2}$ ;  $\sim \lambda^2 H^2 \ln P/H$



⇛ **NEED FOR RESUMMATIONS.**

# RESUMMATION TECHNIQUES

## Flat space :

- **Infrared divergences**

  ↳ QED ; high temperatures ; phase transitions ...

- **Secular divergences**

  ↳ Nonequilibrium systems

⇒ 1/N-expansion ; Schwinger-Dyson equations ; Renormalization group ; two-particle-irreducible techniques ...

## Generalization to dS space:

difficulty : grav. redshift / absence of time-translation invariance

⇒ P-representations of correlators

[ Parentani, Serreau (PRD-2013) ]

# Radiative symmetry restoration in de Sitter space

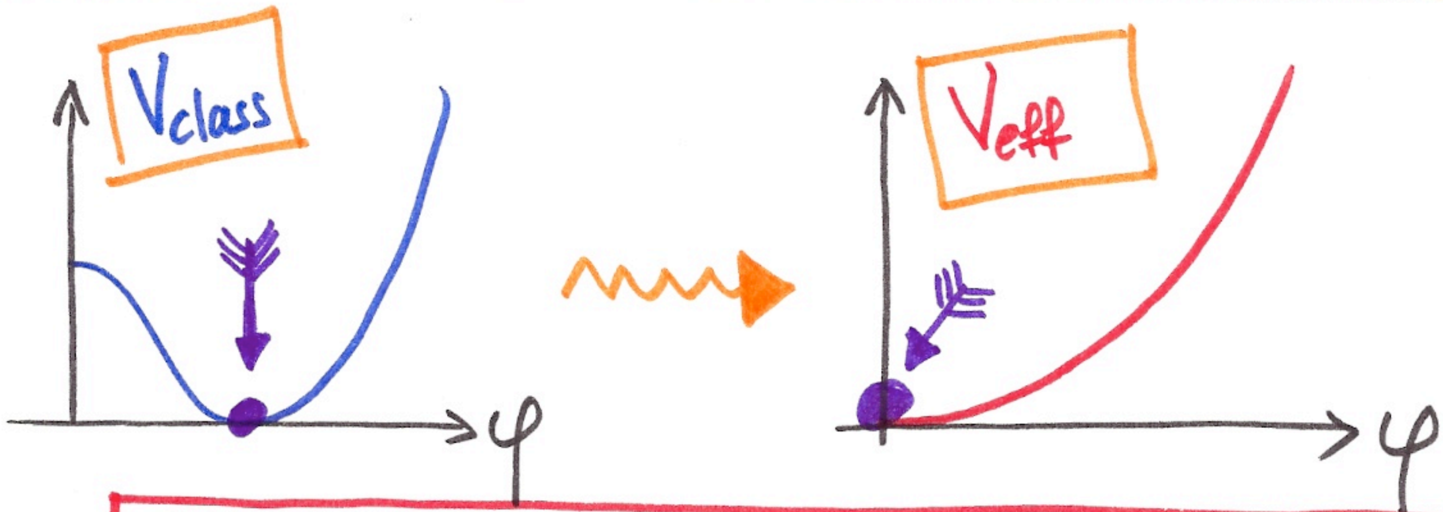
[J. Serreau, PRL ('11) ; PLB ('14)]

O(N) theory :

$$S = -\int d^D x \sqrt{-g} \left\{ \frac{1}{2} g^{\mu\nu} \partial_\mu \vec{\varphi} \cdot \partial_\nu \vec{\varphi} + V_{class}(\vec{\varphi}\cdot\vec{\varphi}) \right\}$$

QUANTUM CORRECTIONS (e.g. large-N limit)

$$\Gamma = -\int d^D x \sqrt{-g} \left\{ \frac{1}{2} g^{\mu\nu} \partial_\mu \vec{\varphi} \cdot \partial_\nu \vec{\varphi} + V_{eff}(\vec{\varphi}\cdot\vec{\varphi}) \right\}$$




⇒ Strong, gravitationally induced infrared quantum fluctuations restore the symmetry in any dimension D !!

# RESULTS and PROSPECTS

- Exact solution of Schwinger-Dyson eqs.

  ⇒ resummation of IR divergences and calculation of field correlators in the deep infrared [F. Gautier, JS, PLB ('13)]

- Large-N limit ⇒ Nonperturbative quantum contributions to non-Gaussian correlators [JS, PLB ('14)]

- Nonperturbative renormalization group [JS, PLB ('14) + Maxime Guilleux's thesis]

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⇒ Correlators beyond large-N : 1/N corrections

⇒ Decoherence during inflation

⇒ Application to (analog) Black Holes