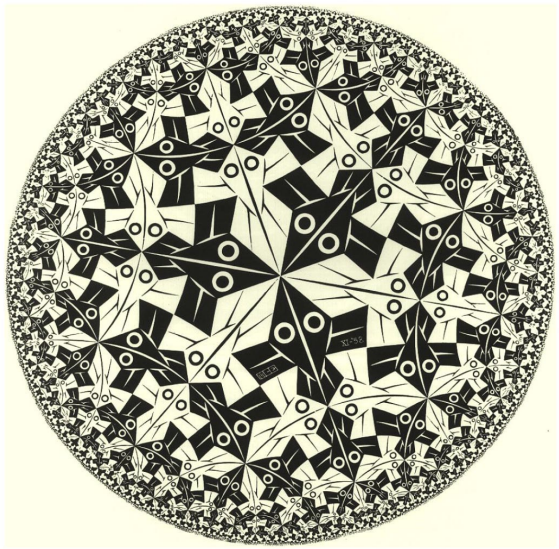
Holographic Thermalization

Joris Vanhoof

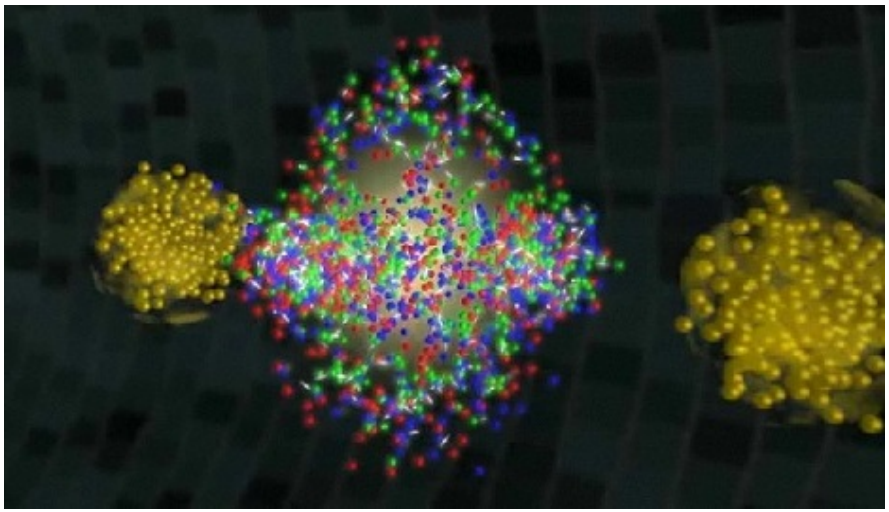
Vrije Universiteit Brussel
and International Solvay Institutes



based on: hep-th/1212.6066, hep-th/1303.7342

Motivation

- Heavy ion collision $\rightarrow$ formation of Quark-Gluon Plasma
- After fast thermalisation $\rightarrow$ described by hydrodynamics
- We want to understand thermalization process itself

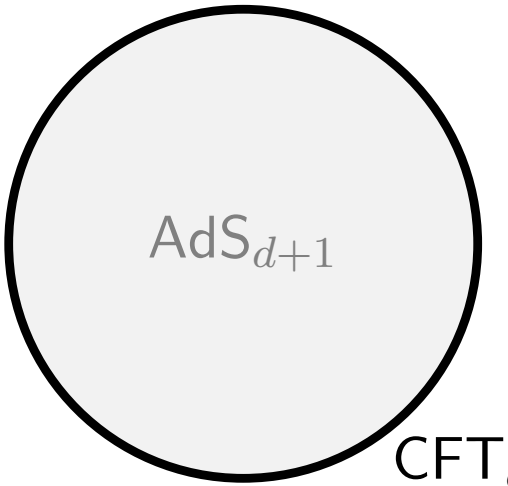


Motivation

- Heavy ion collision $\rightarrow$ formation of Quark-Gluon Plasma
- After fast thermalisation $\rightarrow$ described by hydrodynamics
- We want to understand thermalization process itself
- **Problems:**
  - Strongly coupled dynamics
  - Non-equilibrium dynamics
- **Goal:** Understanding thermalization process using AdS/CFT correspondence
  - Weak/strong correspondence
  - How to implement non-equilibrium dynamics?

Equilibrium states

empty AdS_{d+1} spacetime $\Longleftrightarrow$ CFT at zero temperature

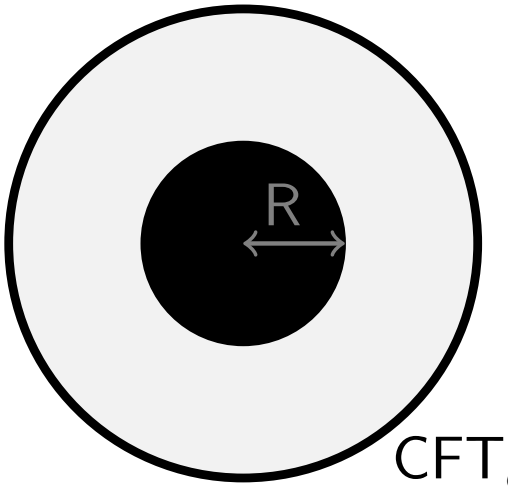


$$\mathrm{d}s^2 = \frac{1}{z^2}\left(\mathrm{d}z^2 - \mathrm{d}t^2 + \mathrm{d}\vec{x}^2\right)$$

$\longrightarrow$ Poincaré patch

Equilibrium states

black hole in AdS_{d+1} spacetime $\Longleftrightarrow$ CFT at nonzero temperature



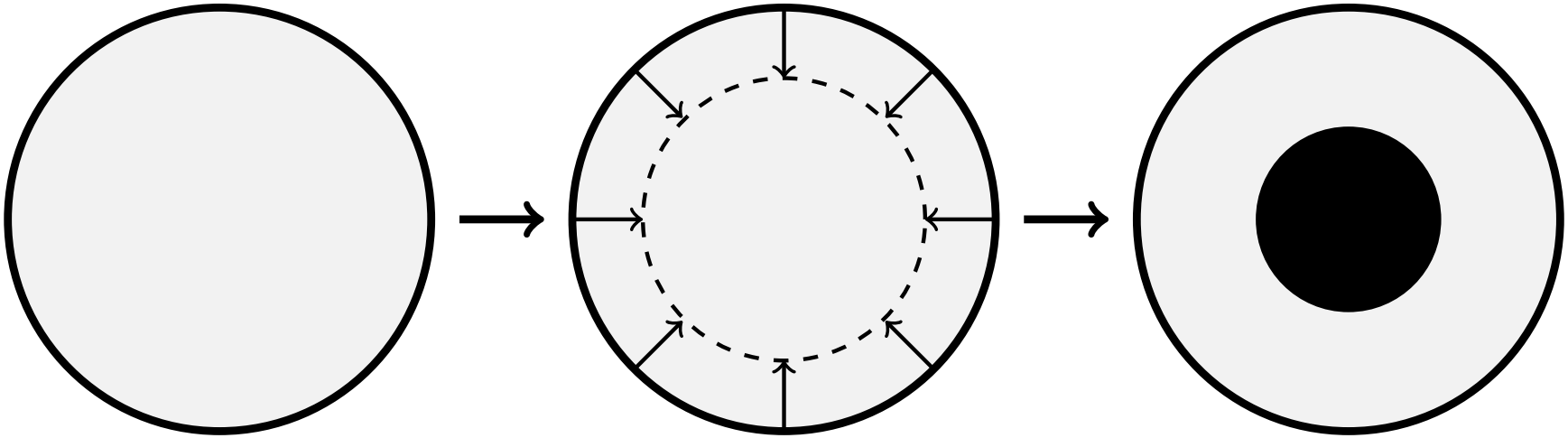
CFT_d
$(T = \frac{dR}{4\pi})$

$$\mathrm{d}s^2 = \frac{1}{z^2}\left(\frac{\mathrm{d}z^2}{1 - R^d z^d} - (1 - R^d z^d)\mathrm{d}t^2 + \mathrm{d}\vec{x}^2\right)$$

$\longrightarrow$ black brane

Thermalization process

equilibrium CFT $(T = 0)$ $\Downarrow$ empty AdS_{d+1}	Injection of energy + thermalisation $\Downarrow$ Infalling shell of null dust	equilibrium CFT $(T \neq 0)$ $\Downarrow$ black hole in AdS_{d+1}

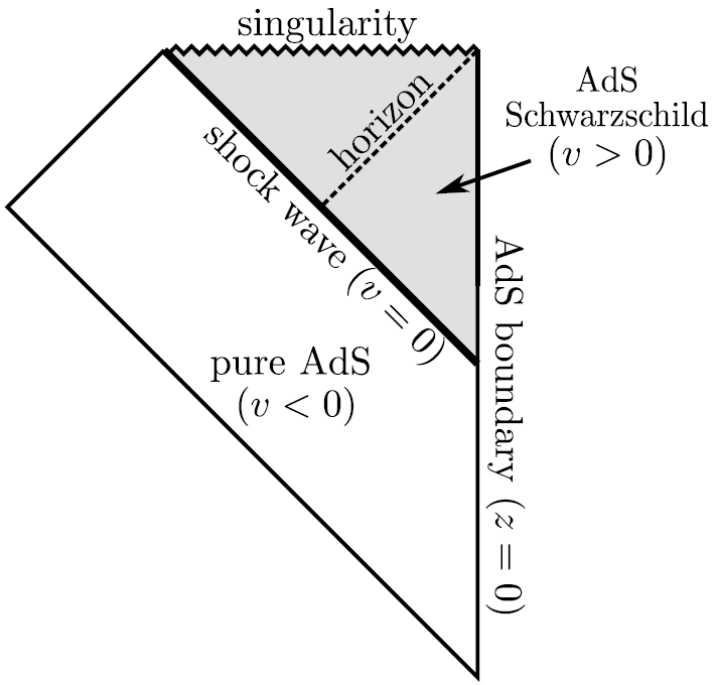


Thermalization process

Vaidya spacetime:

$$\mathrm{d}s^2 = \frac{1}{z^2}\left(-(1-m(v)z^d)\mathrm{d}v^2 - 2\mathrm{d}z\mathrm{d}v + \mathrm{d}\vec{x}^2\right)$$

- Thin shell: $m(v) = \theta(v)R^d$
  - Below shell $(v<0)$: $\mathrm{d}t = \mathrm{d}v + \mathrm{d}z$
    $\hookrightarrow$ pure AdS$_{d+1}$
  - Above shell $(v>0)$: $\mathrm{d}t = \mathrm{d}v + \frac{\mathrm{d}z}{1-R^d z^d}$
    $\hookrightarrow$ black hole AdS$_{d+1}$

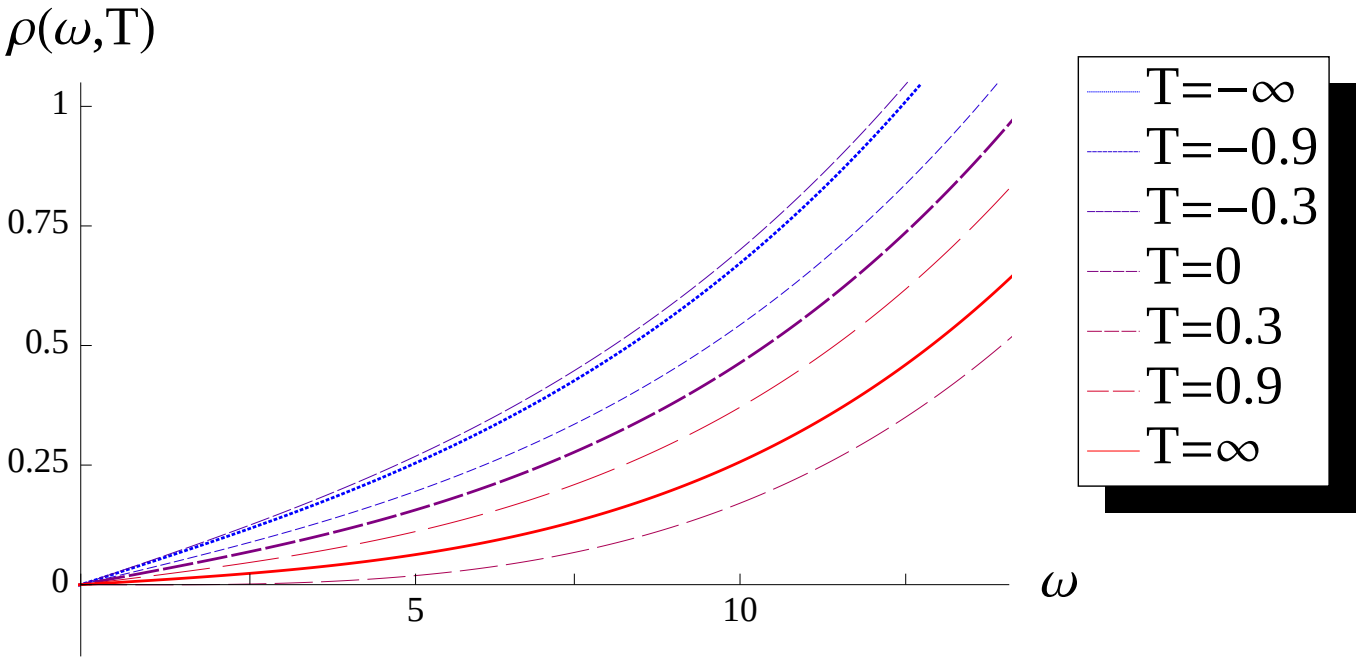


Probes of thermalization

- Two-point functions
  - → (Time-dependent) spectral function
  - → (Time-dependent) temperature
- Spacelike Wilson loops
- Entanglement entropy
  - → Mutual information
  - → Tripartite information

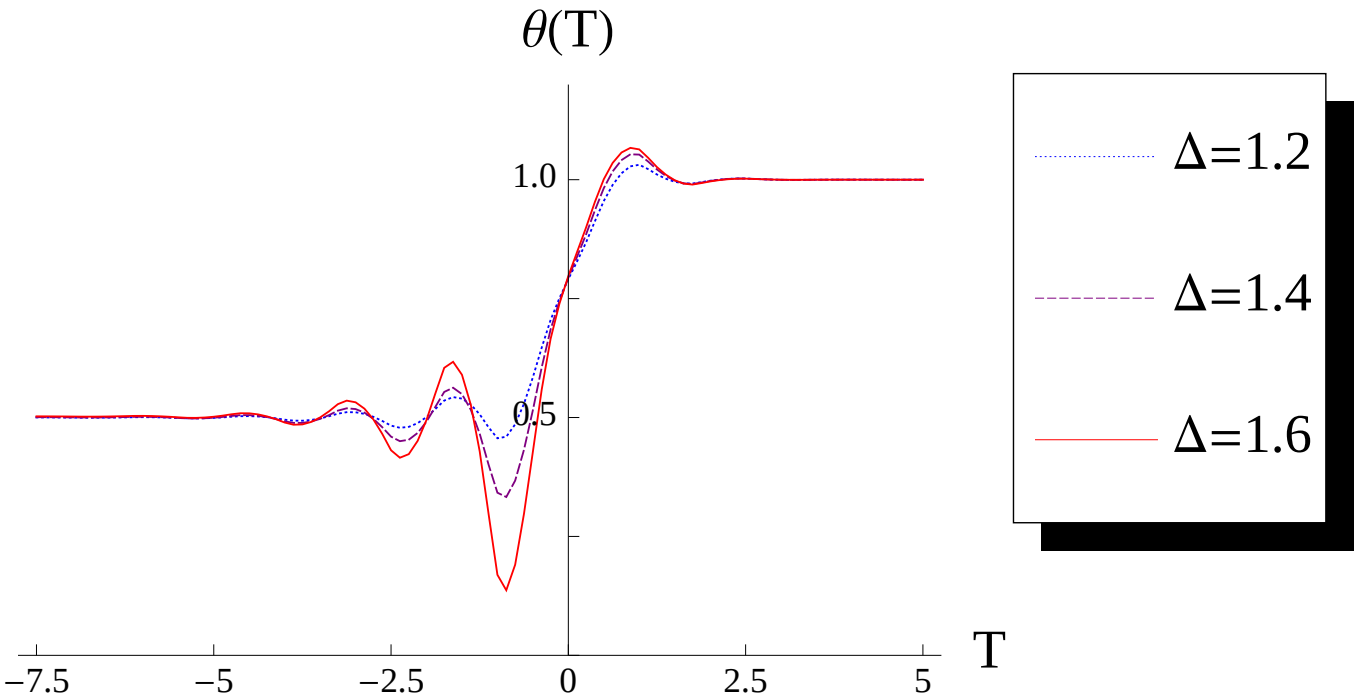
Results

- (Time-dependent) spectral function:
  $(d = 2,\ R_1 = 0.5,\ R_2 = 1,\ \Delta = 2.25)$



Results

- (Time-dependent) temperature: $(d = 2,\ R_1 = 0.5,\ R_2 = 1)$



Thank you for your attention!