

# Holographic Conformal Field Theories

Federico Galli



INFN Firenze

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# Research context

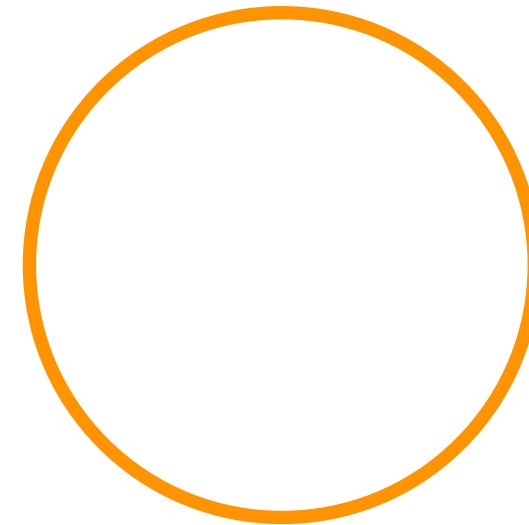
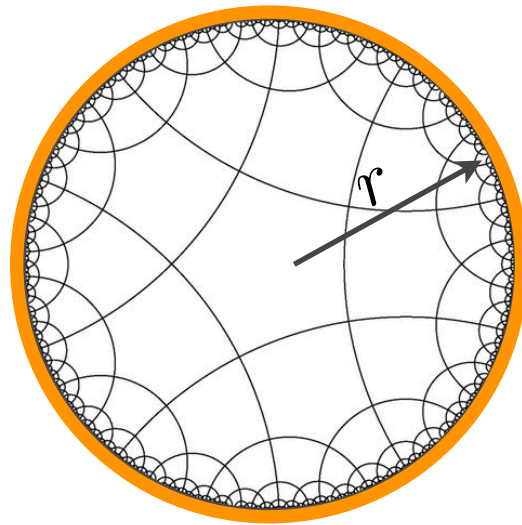
Interface of quantum field theory, gravity and information theory

**Holographic principle:** gravity is an emergent phenomenon resulting from the collective behavior of a large number of non-gravitational degrees of freedom

Promising approach to try answer fundamental questions about the microscopic nature of spacetime and black holes

**AdS/CFT correspondence** gives a concrete realization of the holographic principle and provides a unique framework to study these ideas

# AdS/CFT correspondence



Gravity in Anti de Sitter (AdS) spacetime in  $d+1$  dimensions

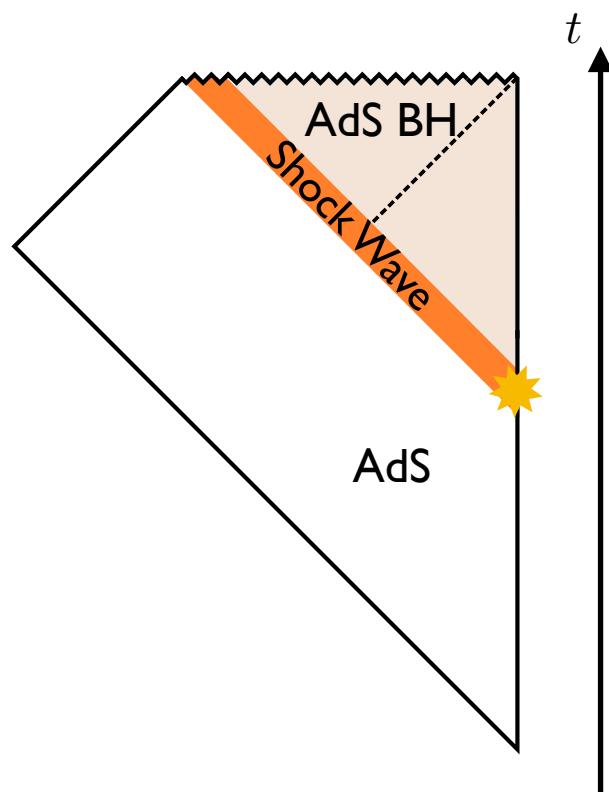
Conformal Field Theory (CFT) in  $d$  dimensions. Gravity-free.

- Weak/strong coupling duality
- Equivalence between the two theories in very different regimes
- Important insight and new understanding of many situations in quantum field theory and gravity

# Applications of the AdS/CFT

- Strongly coupled regime of field theories captured by classical gravity
  - ➔ **Tool** to investigate situations and regimes that are difficult to explore with more traditional methods

## General lessons for **equilibrating systems at strong coupling**



- Inhomogeneous thermalization in heavy-ion collisions

Phys. Rev. Lett. 111 (2013) 231602 , JHEP 1310 (2013) 082  
Balasubramanian, Bernamonti, de Boer, Craps, Franti, **FG**,  
Keski-Vakkuri, Mueller, Schaefer

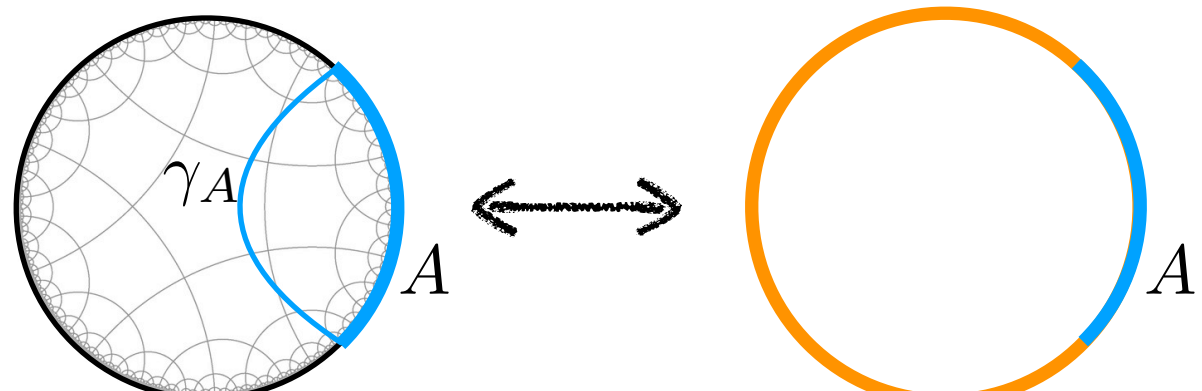
- Holographic pump-probe experiments in CM

JHEP 1410 (2014) 172  
Callebaut, Craps, **FG**, Thompson, Vanhoof, Zaanen, Zhang  
JHEP 1807 (2018) 065, Phys.Rev. D97 (2018) no.8  
Bagrov, Craps, **FG**, Keranen, Keski-Vakkuri, Zaanen

# Holographic CFTs

- Further reaching consequence of holography
  - ➔ Complete **microscopic description of gravity** (in AdS) is captured in the dual field theory description provided **by holographic CFTs**
- **Information theory** has proven to provide a **useful language** and **organizing principle** to explore this deep connection

Key role: measures of **entanglement**


$$S(A) = \frac{\text{Min}(\text{Area}_{\gamma_A})}{4G_N}$$
$$S(A) = -\text{Tr} \rho_A \log \rho_A$$

Relate quantum structure of states in the field theory to simple geometric objects in the dual spacetime

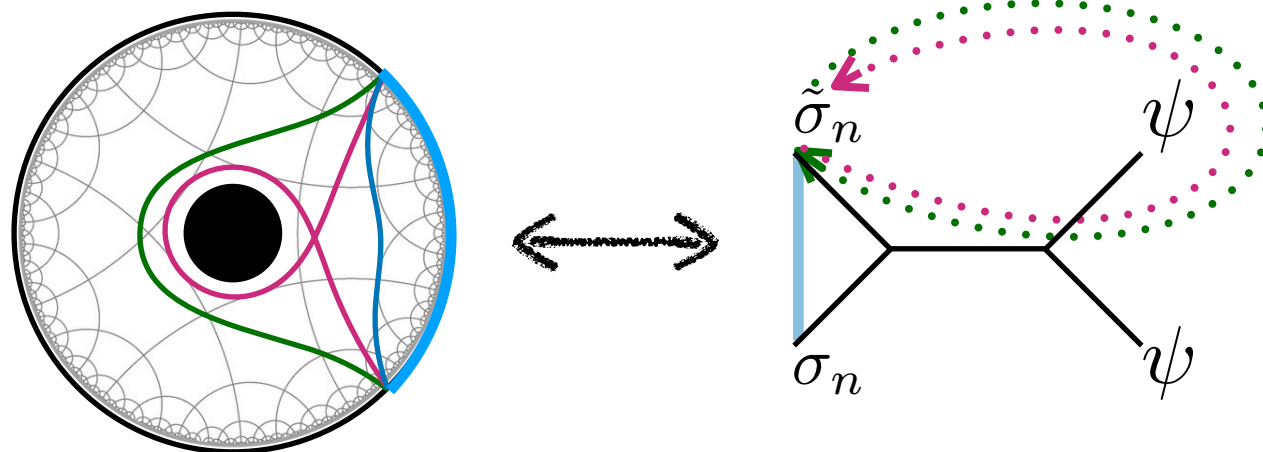
# Holographic CFTs

## ○ Entanglement in CFT and holography

- How do quantum correlations propagate in multipartite systems?
- What is the role of non-minimal extremal surfaces in holography?
- Can we define novel non-spatial measures of entanglement?

## ○ Conformal field theories with holographic duals

- Explicitly relating geometrical and field theory structures
- Better understanding holographic entanglement from the CFT perspective



Phys.Rev.Lett. 123 (2019) no.8

Bernamonti, FG, Hernandez, Myers, Ruan, Simón

JHEP 1612 (2016) 094, JHEP 1708 (2017) 045

Balasubramanian, Bernamonti, Craps, De Jonckheere, **FG**

JHEP 1502 (2015) 171, JHEP 1509 (2015) 110

Asplund, Bernamonti, **FG**, Hartman

Phys.Rev. D84 (2011) 105017

Balasubramanian, Bernamonti, Copland, Craps, **FG**

# Aim of the project

How gravity is encoded in the underlying CFT degrees of freedom? How spacetime emerges from the CFT description?

- **Characterize CFTs with holographic dual and how they encode gravitational structures**
  - Investigating the role of high/low energy states in relation to the existence of multiple gravitational saddles
  - Identifying within conformal theories characteristic features of the emergent AdS gravity
- **Better understand the structure of quantum correlations underlying holographic CFTs**
  - Studying quantum information quantities like quantum circuit complexity
  - Exploring consequences of fundamental constraints valid for quantum systems

# Expectations

- Secondment: will be determined according to the advancement and specific needs of the project
- Training:
  - Stronger background in conformal methods and holography
  - Expand across-field competences in quantum information and statistical physics
- Career:
  - Reinforce independent researcher profile
  - Tackle new important questions in my research domain
  - Tenure track/research position
- Outreach: participate in the local initiatives, e.g. researchers' night and GGI activities



Thank you!