Holographic Thermalization: Quantum Revivals

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arXiv:1403.2632[hep-th]

A QFT system:

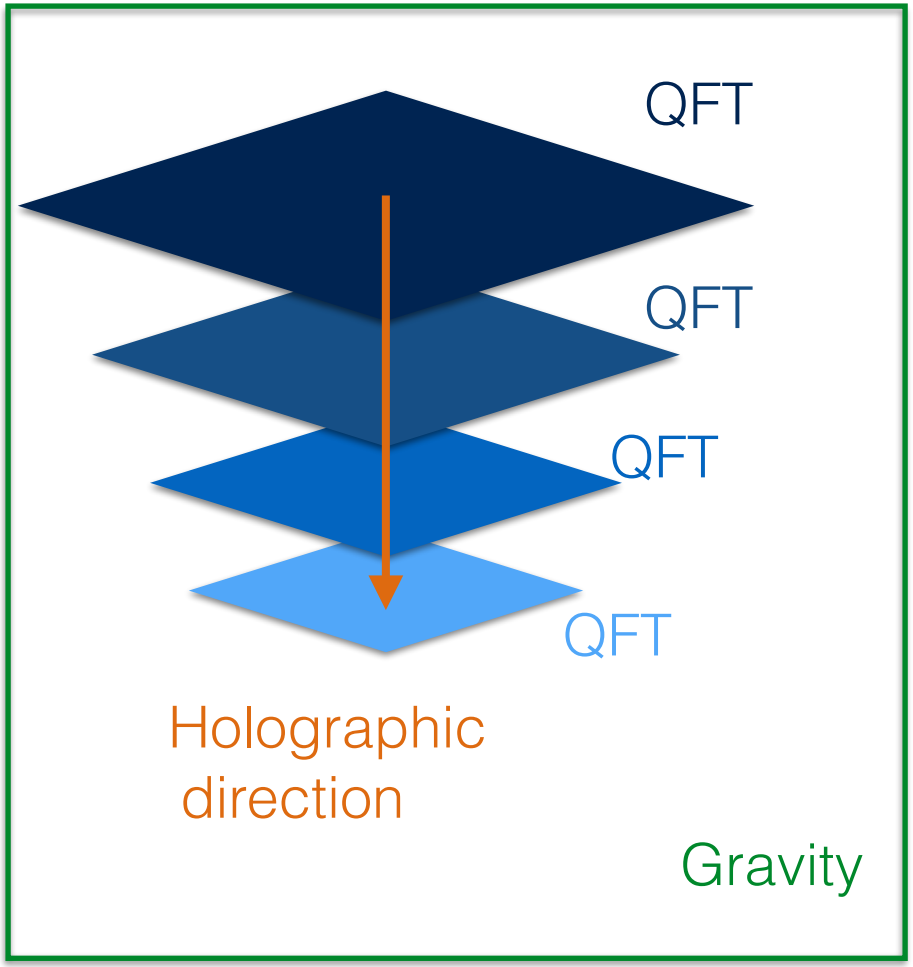
- Strong coupling
- 2+1 dimensions
- Finite size system
- Out of equilibrium
- and Entanglement?

AdS/CFT

Questions from CMT and Holography:

- Thermalization?
- Revivals? Dephasing?
- Simple model for the evolution of Entanglement Entropy?
- Gravitational model? Dual interpretation of Revivals?
- Relation between Gravitational Dynamics and Entanglement?

Fast AdS/CFT, two sides:



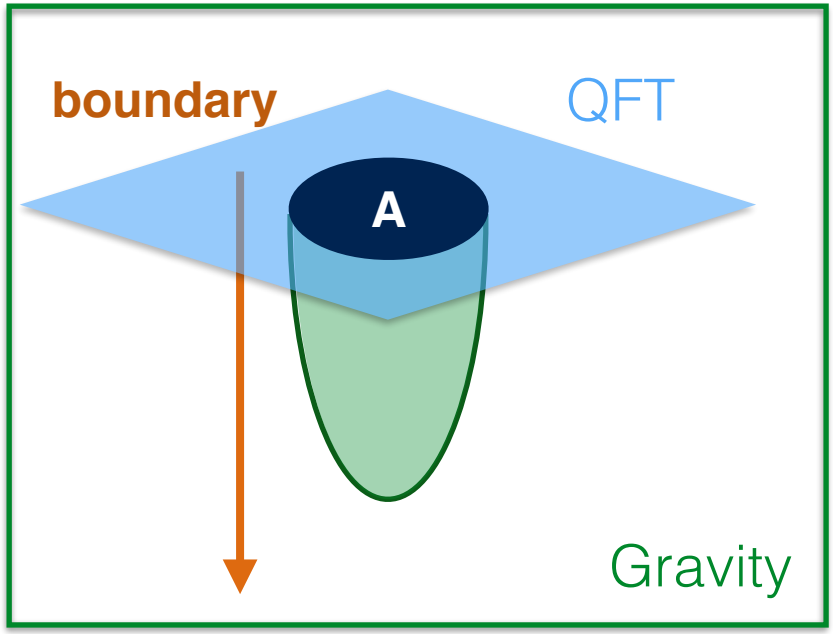
QFT	Gravity
• d dimensions: S2 x R	• d+1 dimensions: AdS4
• State (Vacuum)	• Geometry (AdS4)
• Strong coupling and large N	• Einstein gravity

The observable: Holographic Entanglement Entropy

EE is a measure of quantum correlations between a subsystem and its complementary

EE QFT

$$S_A = -Tr_A(\rho_A \log \rho_A)$$



HEE

$$S_A = \frac{Area(\gamma_A)}{4G_N}$$

γ_A : extremal curve

arXiv:0905.0932[hep-th]

✳ **And the metric!**

Our Holographic Model for Thermalization

Gravitational collapse of a scalar shell in AdS4

because

Scalar field in AdS4

✳ How?

✳ Always?

Final Black Hole

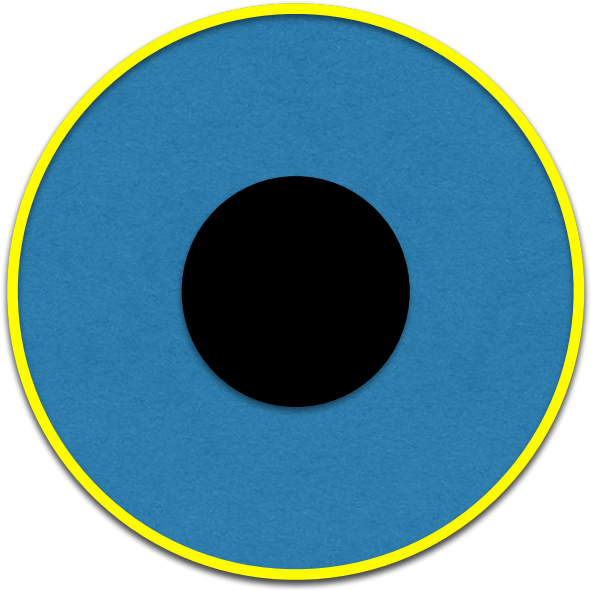
Some state in QFT 2+1

Equilibirium State

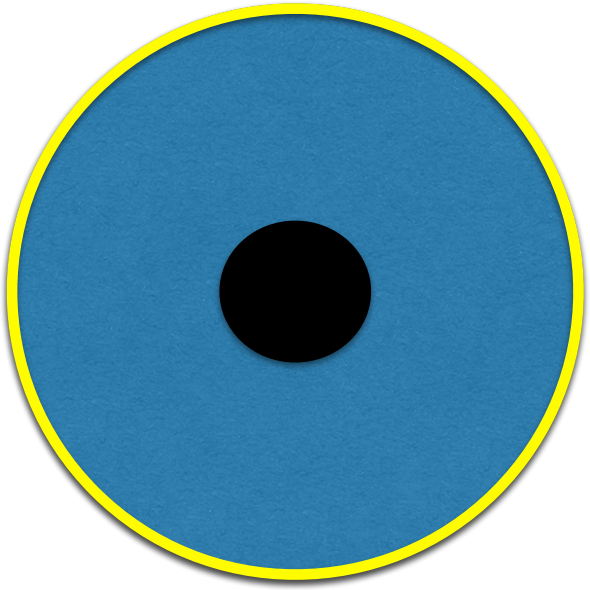
Our Holographic Model: Bounces-Revivals

For small masses of the final BH: **Bouncing geometry**

The scalar field bounces with the boundary before (if) forming a BH



Large BH



Small BH

arXiv:1104.3702[gr-qc]

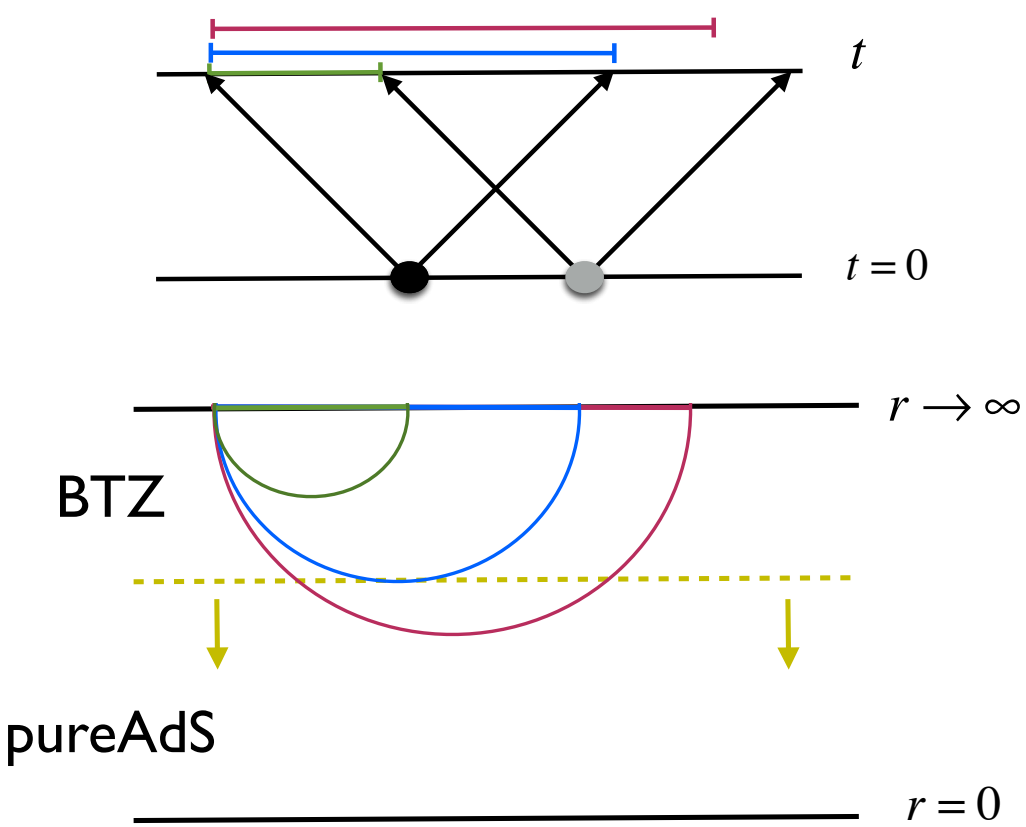
What we already know

Quantum quench in CFT2 on a infinite space: kinematical model for EE

arXiv:cond-mat/0503393

AdS3 with an infalling shell of null dust: Vaidya model

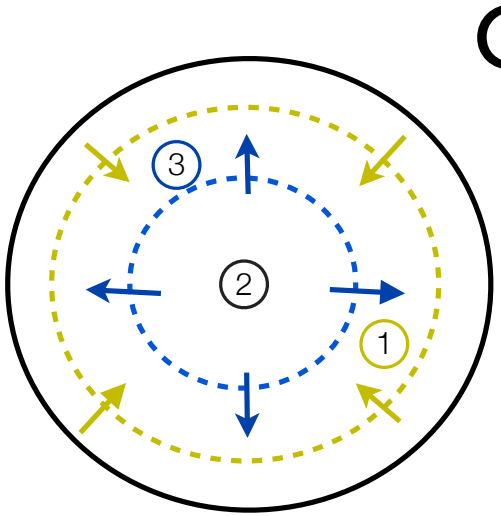
arXiv:1006.4090[hep-th]

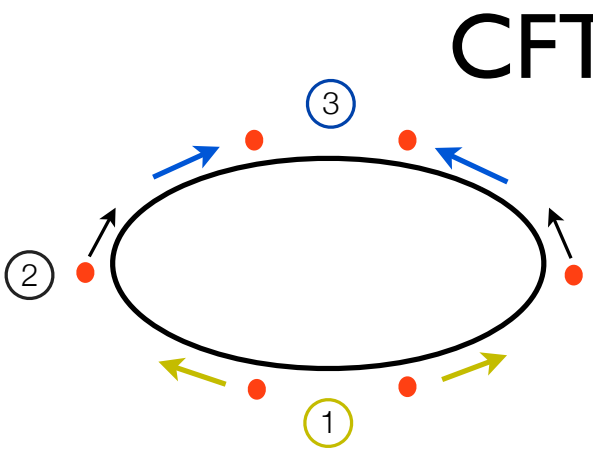


The radial position of the shell captures the separation of entangled components

arXiv:1302.5703 [hep-th]

What about 2+1 and Finite Size?





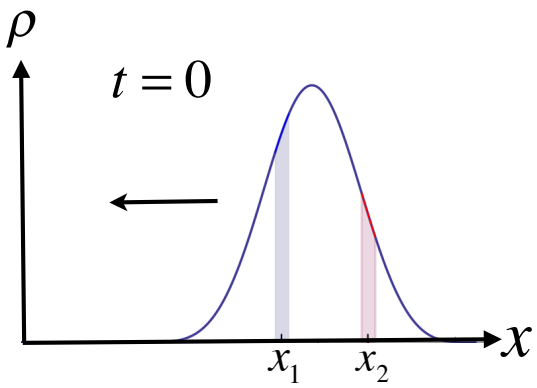
1. Entangled pairs behave much as in the non compact case
2. Bounce or collapse? Interactions are crucial
3. Partial reconstruction of the state at t0=L/2v. Revivals.

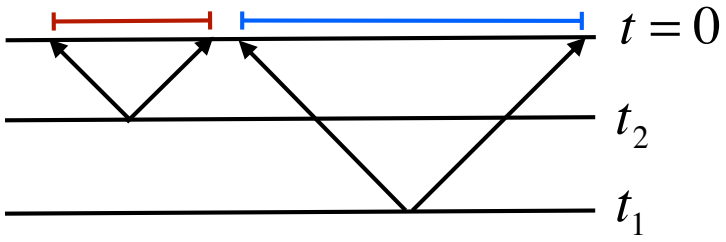
✳ Dual interpretation of the bounces!

QFT interpretation: shape of the pulse

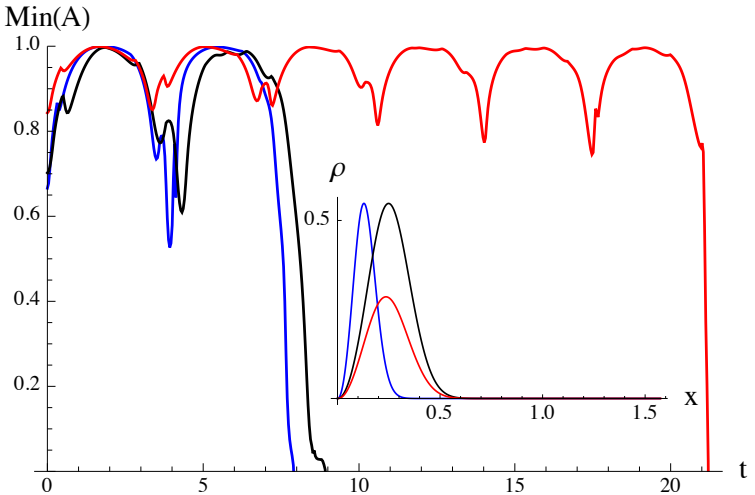
$$M = \frac{1}{2}\int_0^{\pi/2} \rho(t,x)dx$$

- Broadness: entanglement over many length scales





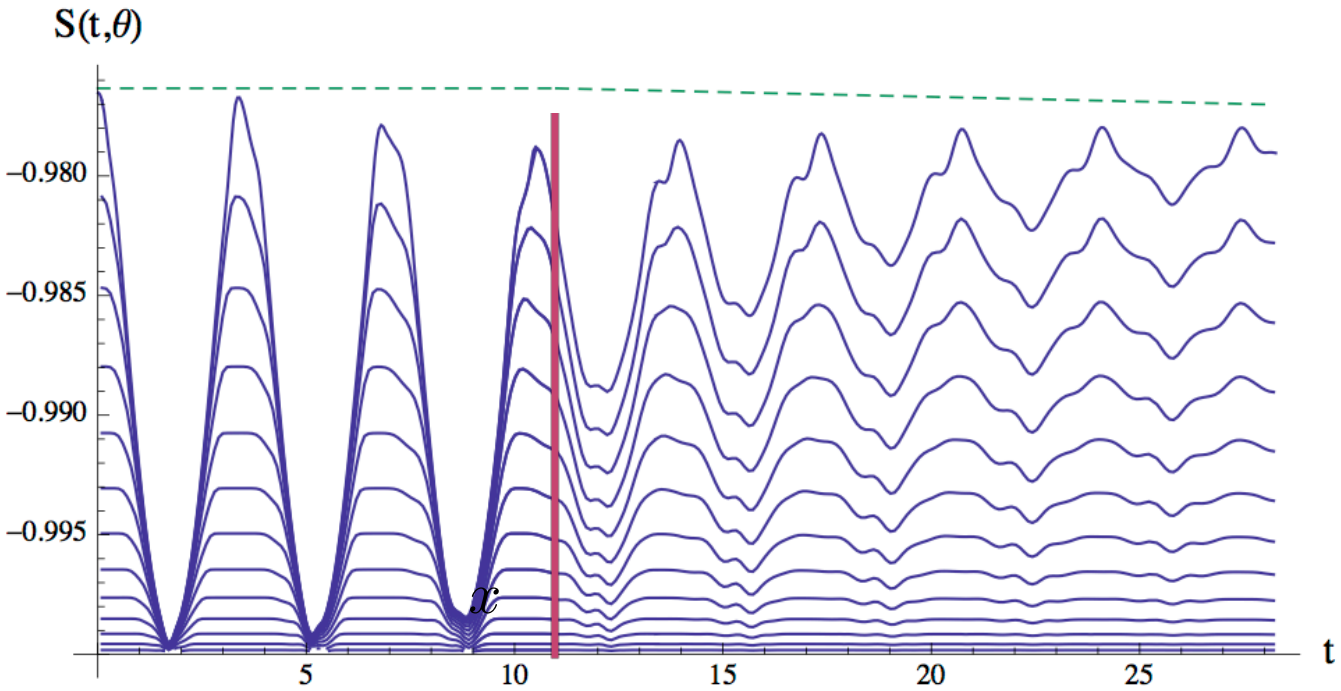
- Heigth: measure of the number of strongly correlated pairs



Dephasing and Self Reconstruction: Narrow pulses

- Periodicites $t0 \gtrsim \pi$ $(Mass \uparrow \Rightarrow t0 \uparrow)$
- Change of rho mostly at the origin
- Propagation of rho at cte v

➡ Clear image of propagation + interactions

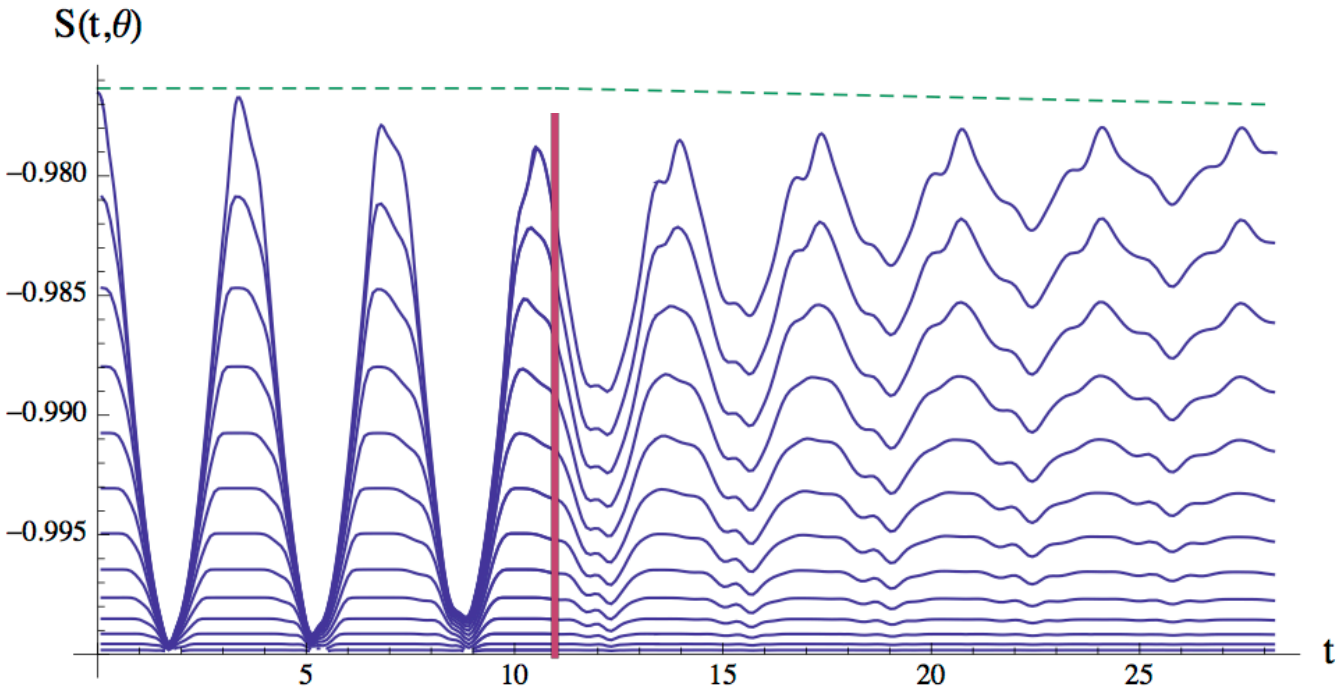


Relaxation: Narrow pulses

- Fraction of the pulse sharpens and give rise to a horizon

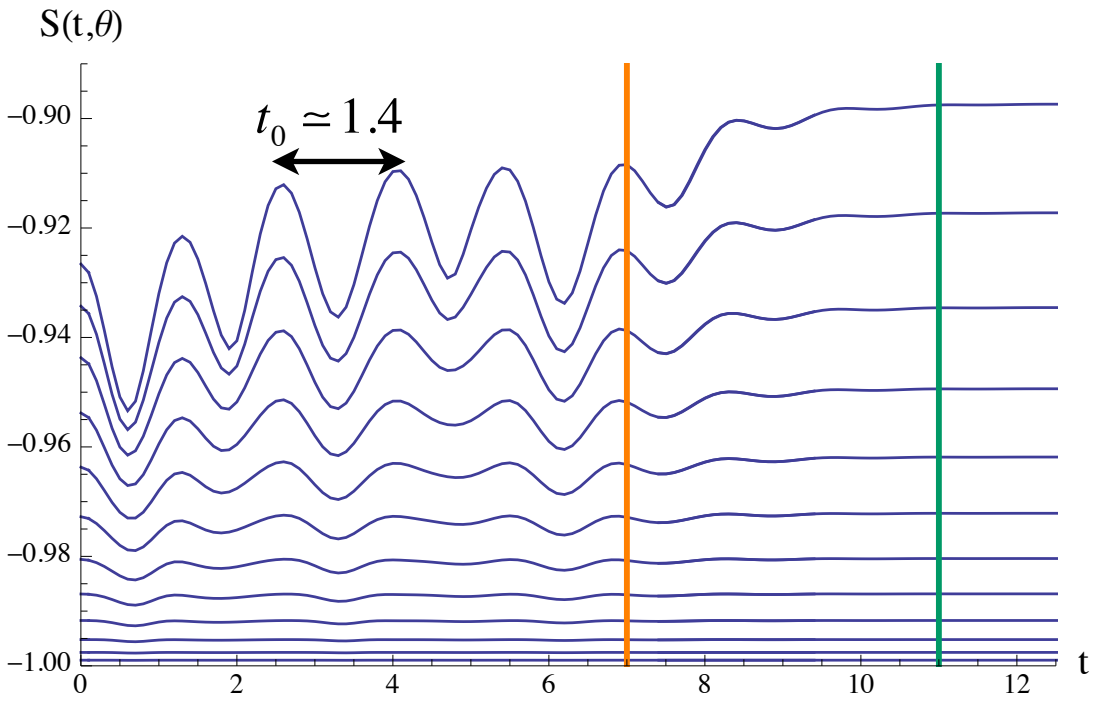
- Stepwise growth of the BH

➡ Relaxation triggered by a subsystem



Dephasing, Self Reconstruction and Relaxation: Broad pulses

- periodicity $t0 \gtrsim \pi/3$ **experiments?**
- Below some mass no horizon formation
- Partial decoherence unfavored



Conclusions:

- Holographic model for revivals in 2+1 in a finite size system
- Different types of thermalization depending on the initial entanglement pattern (for small energies)
- Propagation + Interactions model for the dynamics of EE
- Holographic direction: entanglement scale
- Very deep and clear relation between dynamics of gravity and entanglement

Thank you!