Entanglement Shadows

Laurens Kabir

University of Amsterdam

February 4, 2015

Contains results from "Casting Shadows on Holographic Reconstruction"
by B. Freivogel, R. Jefferson, L. Kabir, B. Mosk and I-S. Yang
hep-th/1412.5175

Outline

Entanglement Entropy

General and useful tool to measure correlations in quantum system which is dived in two parts

$$S = -\mathrm{Tr}\rho_A \log \rho_A \qquad \rho_A = \mathrm{Tr}_B \rho_{AB}$$

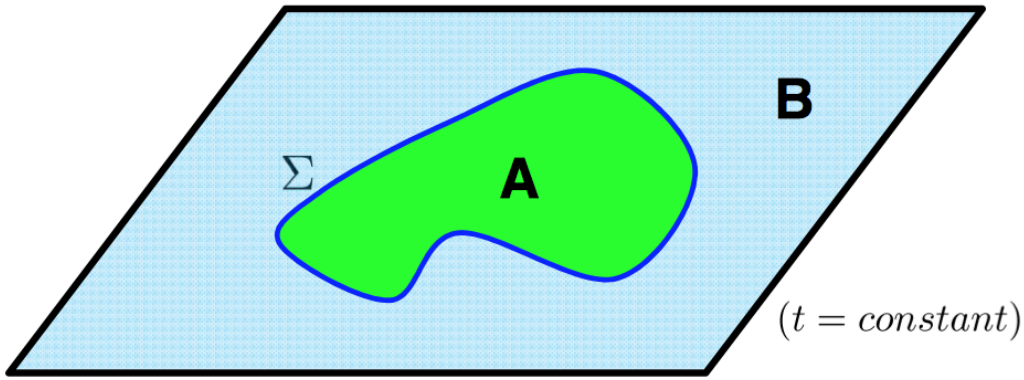


Image: R. Myers

Holographic Entanglement Entropy

Ryu & Takayanagi '06

$$S(A) = \min_{\partial V = \Sigma} \frac{A_V}{4G}$$

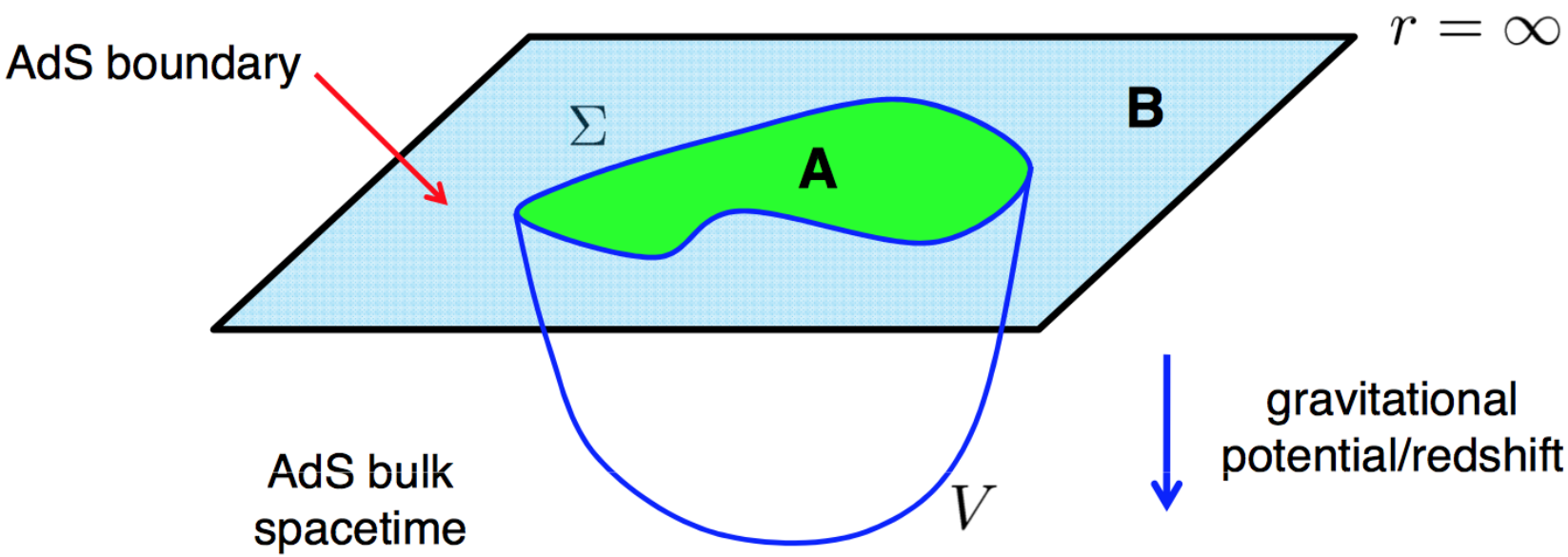
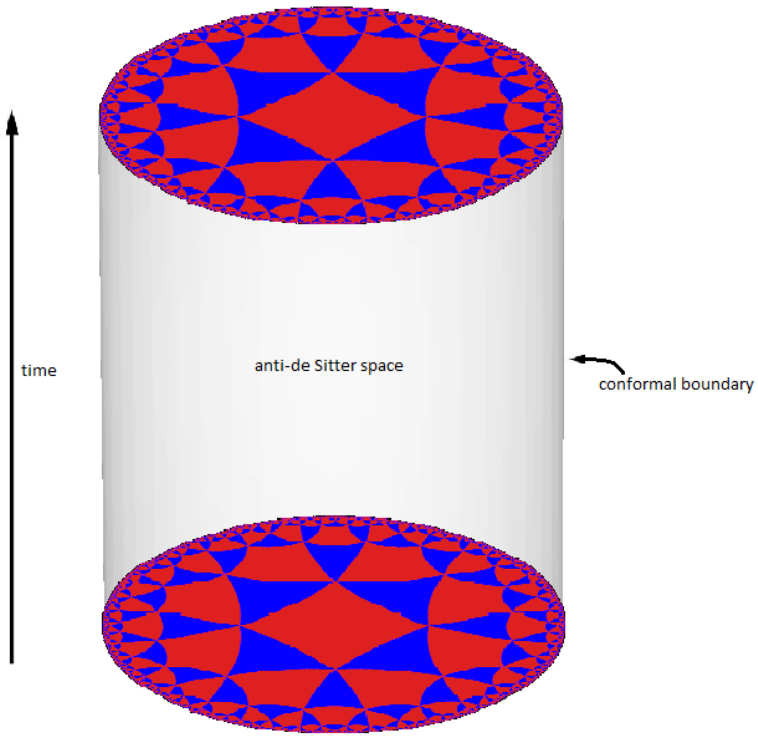
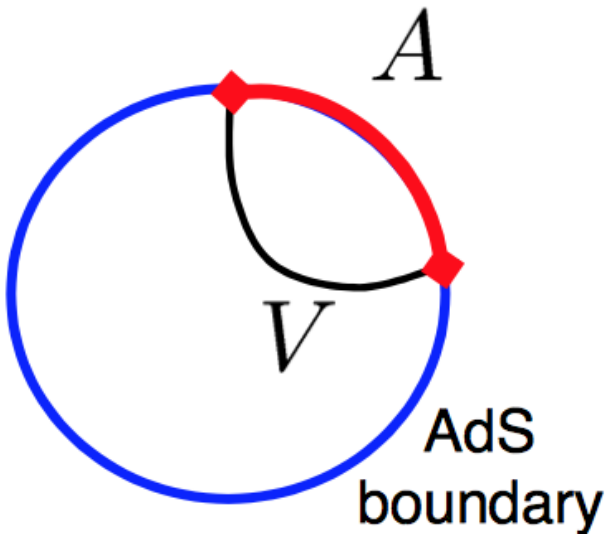


Image: R. Myers



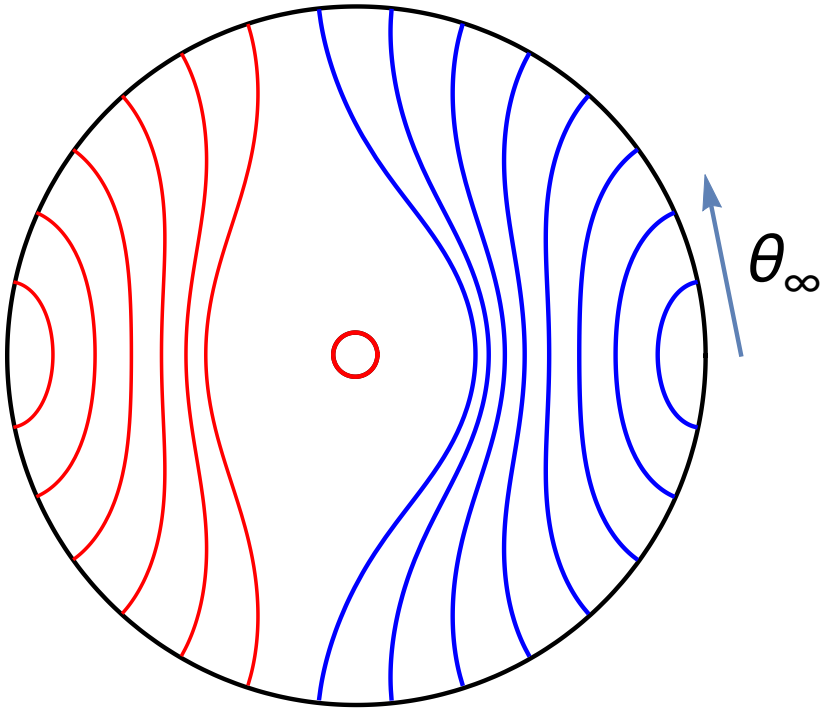


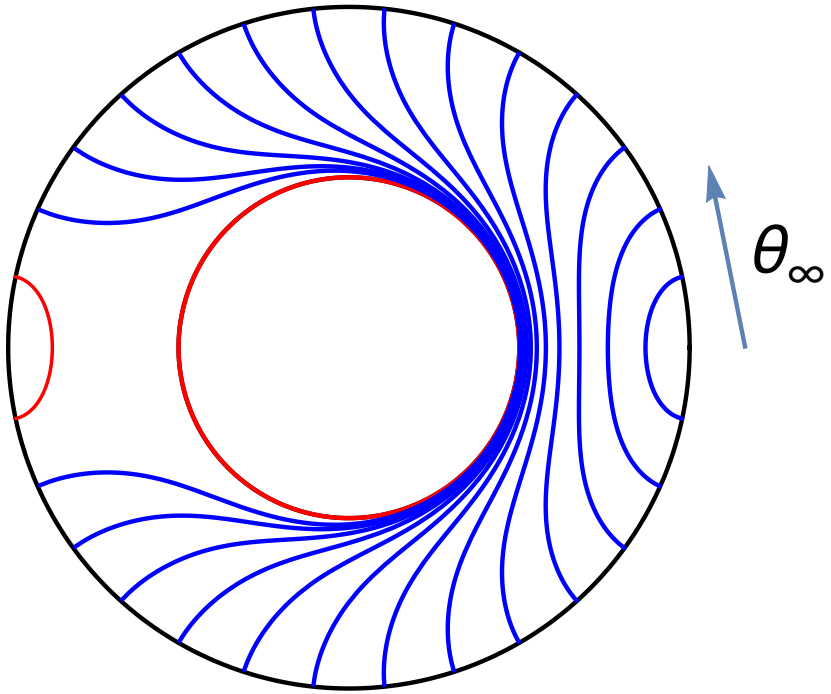
Reveals a link between geometry and quantum information

Reconstructing the bulk from the boundary:
Gravitation from entanglement
[T Faulkner, M Guica, T Hartman, R Myers, M Van Raamsdonk, '13]

Entanglement Shadows

Example: put a black hole in AdS and study the RT-surfaces for different boundary regions





Holographic Shadows

What about other probes?

	Minimal Area	Wilson Loop	Causal
$d = 2,\ r_H \ll l_{\mathrm{AdS}}$	$\sim l_{\mathrm{AdS}}$	$\sim l_{\mathrm{AdS}}$	$\sim l_{\mathrm{AdS}}$
$d = 2,\ r_H \gg l_{\mathrm{AdS}}$	$\sim e^{-r_H/l_{\mathrm{AdS}}}$	$\sim r_H$	$\sim e^{-r_H/l_{\mathrm{AdS}}}$
$d > 2,\ r_H \ll l_{\mathrm{AdS}}$	$\sim r_H$	$\sim (r_H l_{\mathrm{AdS}})^{1/2}$	$\sim e^{-l_{\mathrm{AdS}}/r_H}$
$d > 2,\ r_H \gg l_{\mathrm{AdS}}$	$\sim e^{-r_H/l_{\mathrm{AdS}}}$	$\sim r_H$	$\sim e^{-r_H/l_{\mathrm{AdS}}}$

Table : Shadow summary for various probes in $SAdS_{d+1}$.

Outlook

Shadows are very generic.

Outlook

Shadows are very generic.

And they leave a lot of questions:

- how does bulk field reconstruction work in the shadow?
- can Einstein equations still be reconstructed?
- how are bulk dof's in the shadow region encoded in the CFT?

Summary

Holographic entanglement entropy is a wonderful probe connecting geometry and entanglement, although shadow regions form a serious obstacle to reconstruct (local) bulk physics from the CFT.

Summary

Holographic entanglement entropy is a wonderful probe connecting geometry and entanglement, although shadow regions form a serious obstacle to reconstruct (local) bulk physics from the CFT.

Thanks for your attention!

Questions?

Backup Slide: Wilson loops

Wilson loops can encounter a deconfining phase transition, which make them have a larger shadow

Only for a small BTZ black hole, this transition will happen after $\theta_\infty > \frac{\pi}{2}$, hence it will never encounter this deconfining transition.