Holographic Complexity of Domain Wall Spacetimes

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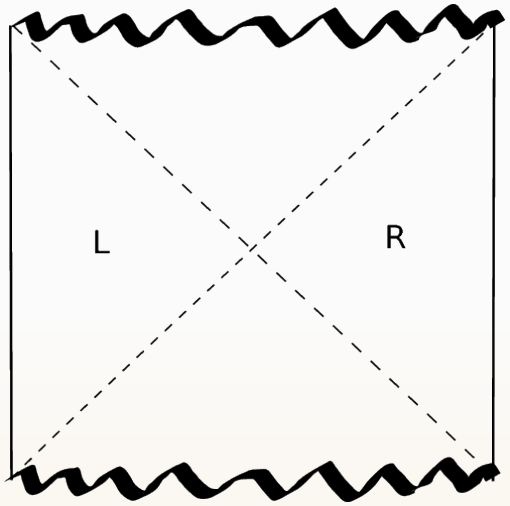
Introduction

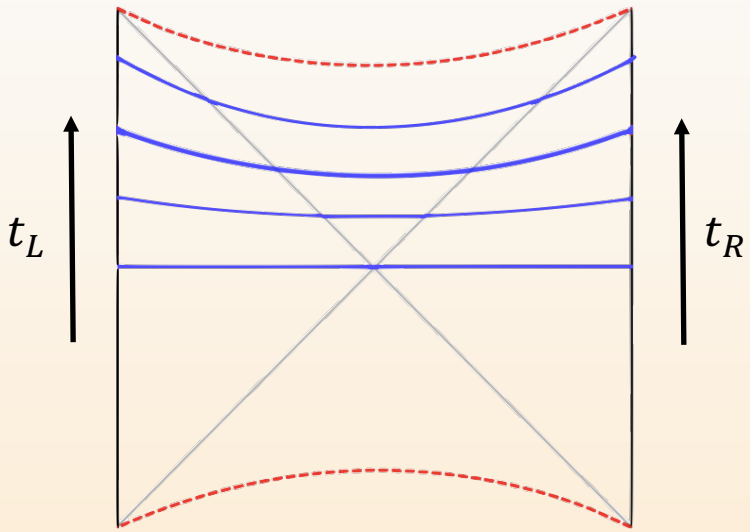


Penrose conformal diagram of
an AdS-Schwarzschild spacetime

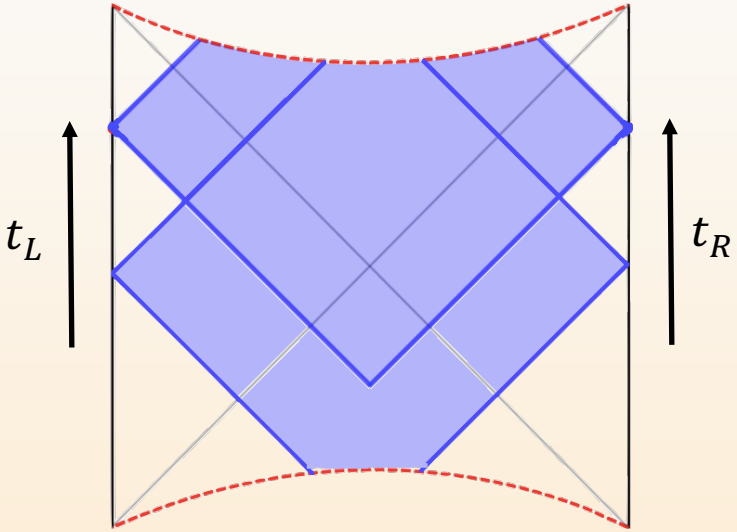
- AdS/CFT correspondence
  - Spacetime geometry in D-dimensional bulk
  - Quantum state on $(D-1)$-dimensional boundary

Wormholes

- Outside the horizon: Static spacetimes
- Inside the horizon: untraversable wormholes
- What is happening there?



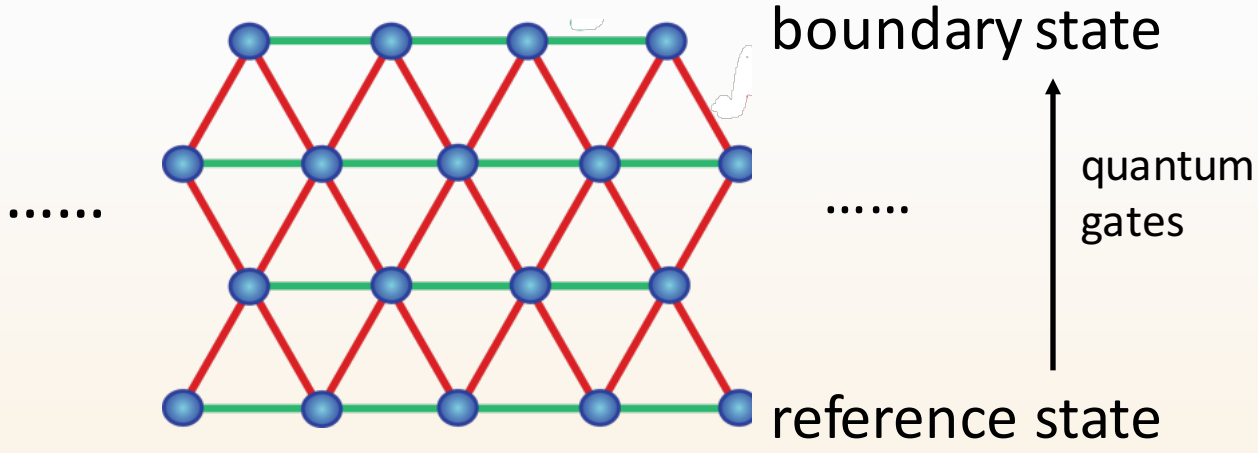
extremal surface



Wheeler-DeWitt patch

Complexity

- On the boundary



$$Complexity = The\ minimum\ number\ of\ quantum\ gates$$

Two conjectures on holographic complexity

- Complexity = Volume (C=V)

$$\mathcal{C} = \frac{V}{G_N l_{AdS}}$$

- Complexity = Action (C=A)

$$\mathcal{C} = \frac{\mathcal{A}}{\pi\hbar}$$

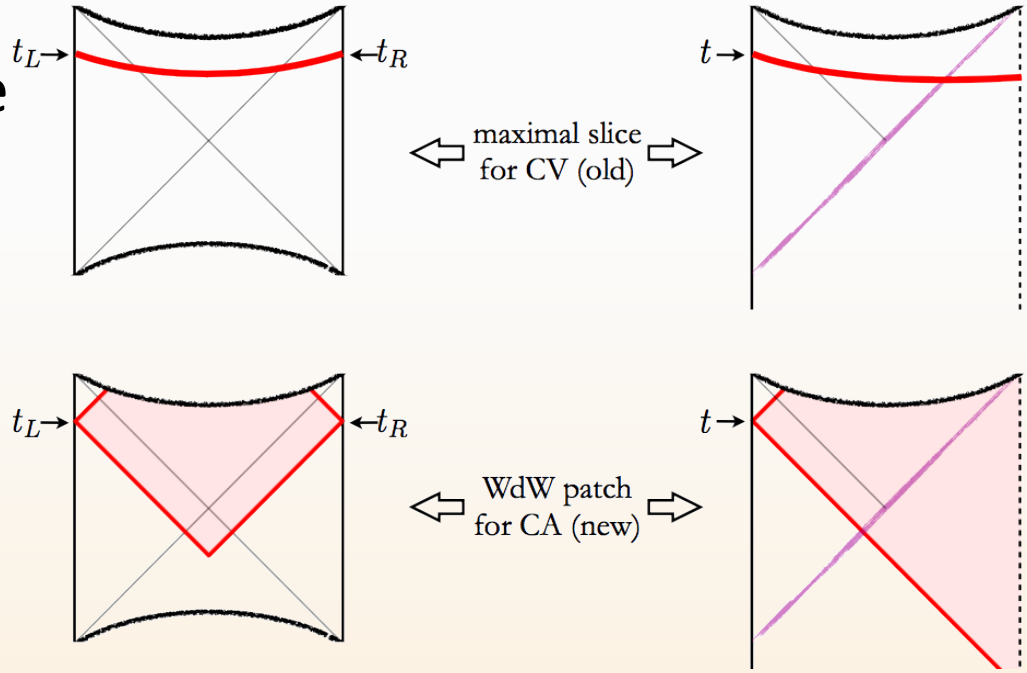


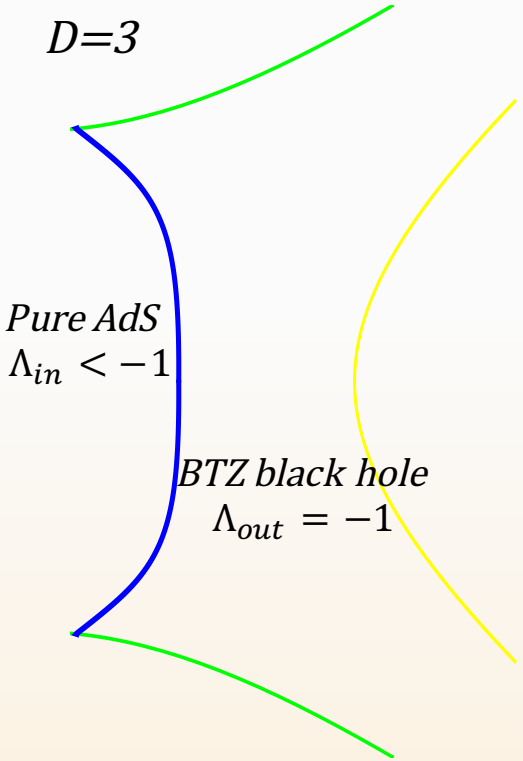
Figure 1 in [A.R. Brown, D.A. Roberts, L. Susskind, B. Swingle and Y. Zhao, Phys. Rev. D93 (2016) no.8, 086006]

How to distinguish the two conjectures?

- C=V vs C=A
- They together passed many tests in shock wave spacetimes

- Volume and action have different sensitivities to cosmological constants
- Construct a spacetime with two different cosmological constants

Domain wall spacetimes



Blue: domain wall trajectory
Green: singularity
Yellow: infinity

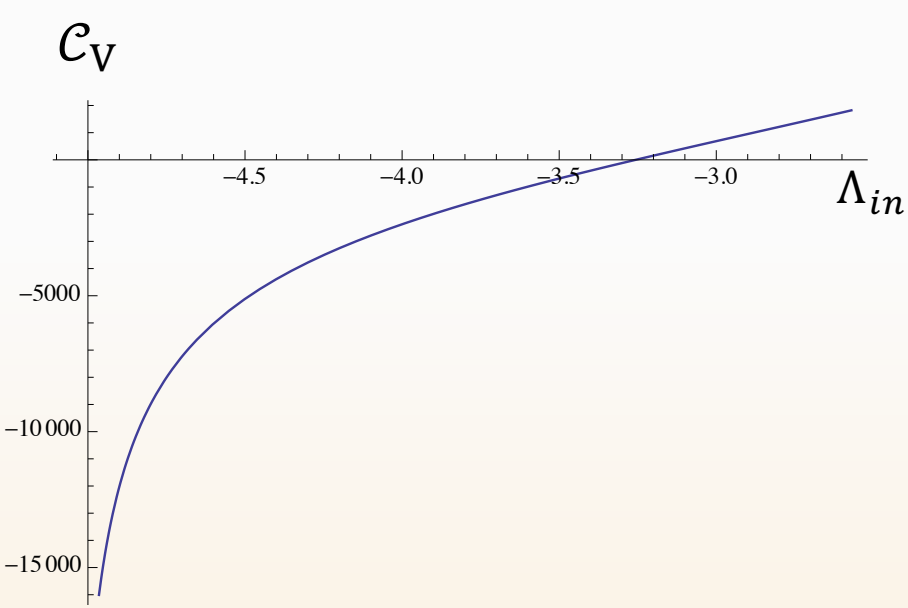
Spherical symmetry
Time reversal symmetry

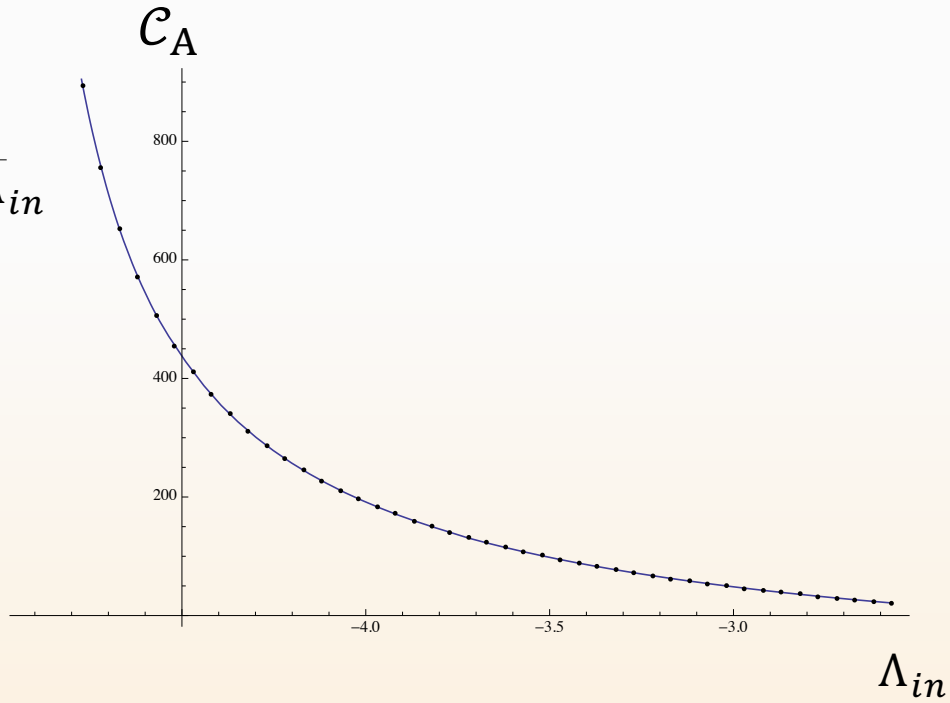
- Domain wall: a kind of matter of co-dimension 1
- Pasting two pieces of known spacetimes with a domain wall
- Reference state: pure AdS (Λ=-1)

$$\mathcal{C} = \mathcal{C}_{domain\ wall} - \mathcal{C}_{pure\ AdS}$$

- $t_{bndy} = 0$
- Calculate $\mathcal{C}_V$ and $\mathcal{C}_A$

The two conjectures are distinguished!



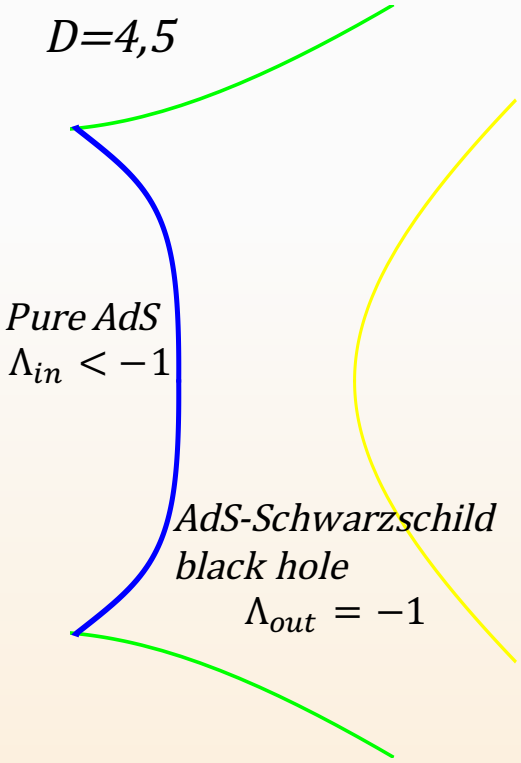


$D=3$

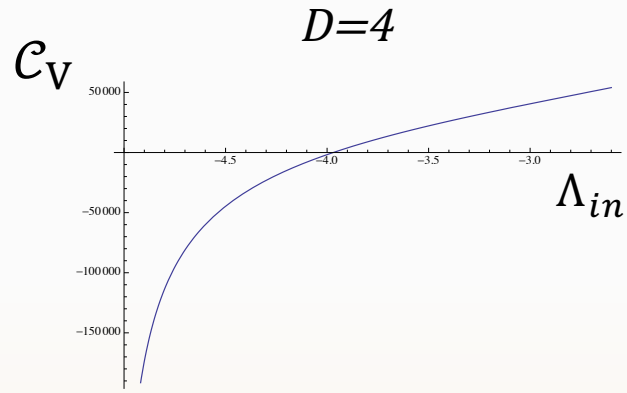
Domain wall tension $\kappa = 1.25$
Mass of BTZ black hole $M = 10^6$

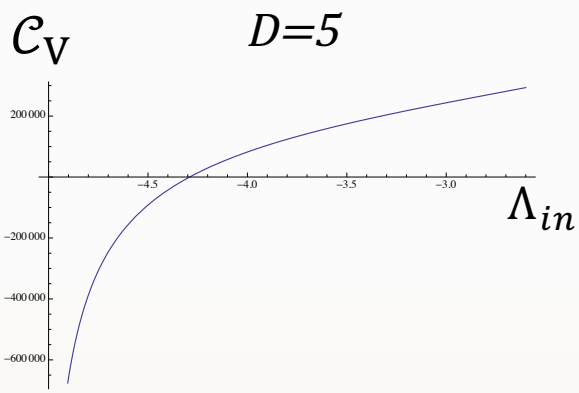
$-5.06 < \Lambda_{in} < -2.57$

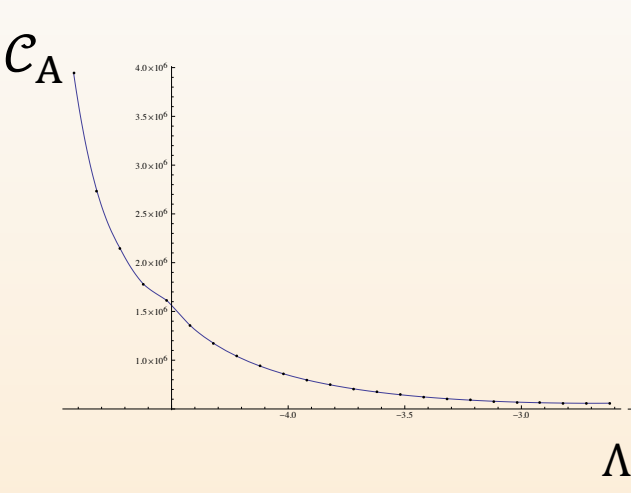
In higher dimensions

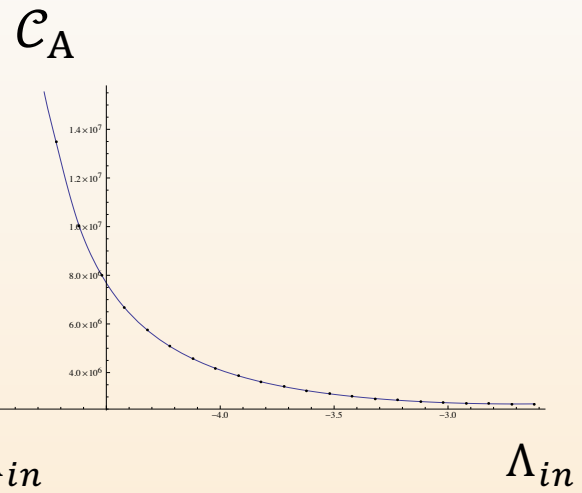


$\kappa = 1.25$
$M = 10^6$









$-5.06 < \Lambda_{in} < -2.57$

C=V or C=A?

- We have distinguished the two conjectures.
- To know which conjecture is more reliable, we need to estimate the complexity on the boundary.

Acknowledgement

- Professor Donald Marolf
- Zicao Fu

Thank you!