Horizons and Holographic Screen Sequestration

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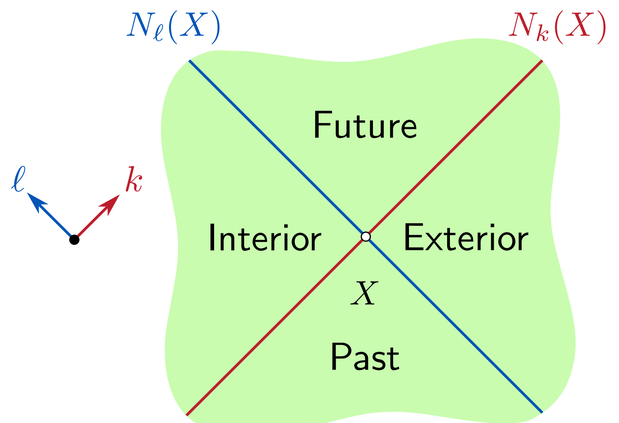
We find that apparent horizons must be confined to one of four regions defined by the null congruences $N_k(X)$, $N_\ell(X)$ of an HRT surface X. That is, a holographic screen is either entirely contained in, or entirely excluded from a single boundary's entanglement wedge.

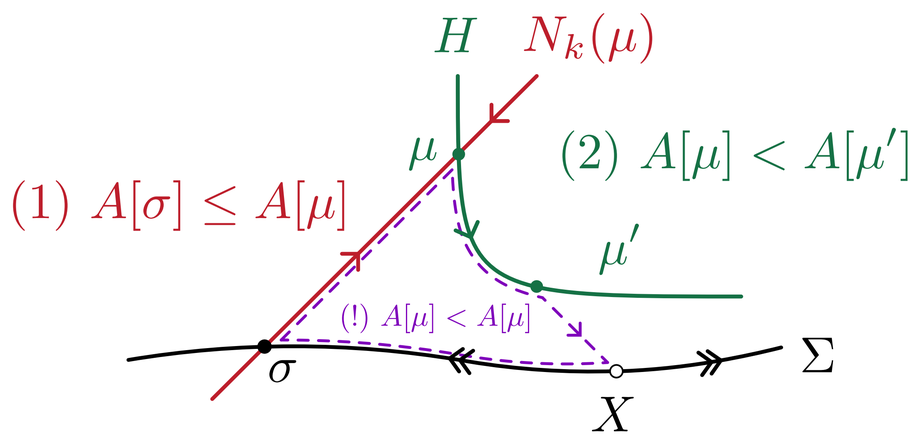


Motivation

- The ***outer entropy*** of Engelhardt & Wall [1] provides a coarse-grained entropy for holographic spacetimes. It is the von Neumann entropy of a state dual to a spacetime under the constraint that field data to the exterior of a minimar surface μ is held fixed.
- However, it is only defined with respect to ***spacelike*** holographic screens. Timelike screens generically appear in cosmological spacetimes and black hole interiors, but there is no known prescription for a coarse-grained entropy in these scenarios.
- In sharpening our understanding of timelike screens as a coarse-grained entropy, we find it useful to ***map out where holographic screens and HRT surfaces can be located relative to each other.***

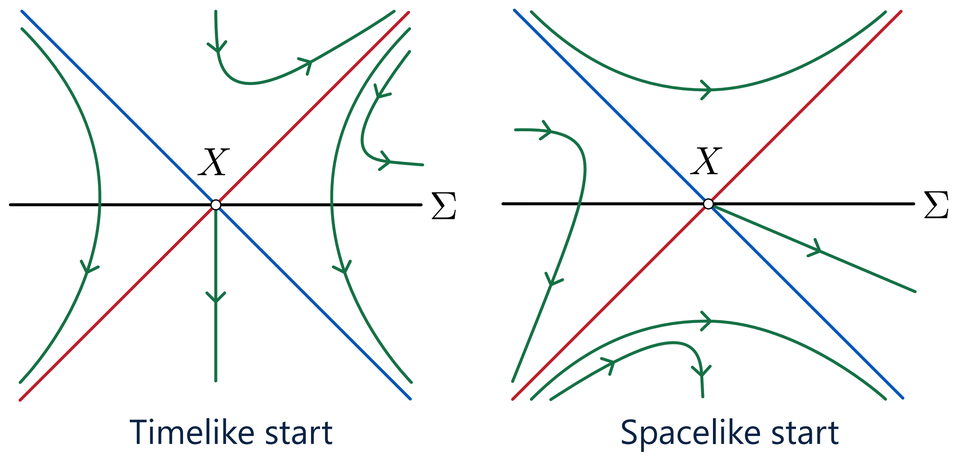
Rules of the game

- Let us assume the null energy condition $T_{ab}k^a k^b \geq 0$, and work with ***future holographic screens*** H without loss of generality.
- When comparing minimar surfaces μ to HRT surfaces X, note that:
  - (1) Since $\theta_k = 0$ at μ, by the Raychaudhuri equation, $\nabla_k \theta_k \leq 0$, so cross-sectional areas along $N_k(\mu)$ are ***non-decreasing*** toward μ.
  - (2) Areas of μ foliating a screen H ***monotonically increase*** toward the exterior (past) for spacelike (timelike) segments [2].
  - (3) There exists a Cauchy slice Σ containing the HRT surface X such that any Cauchy-splitting surface σ has area ***at least as large as*** X.



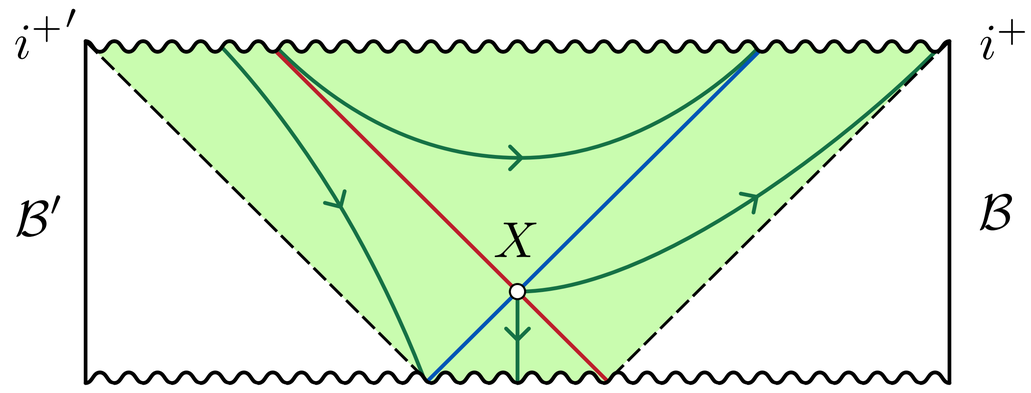
Locating the holographic screen

- Given a holographic spacetime with an HRT surface X, the above is ***sufficient to constrain where holographic screens can live.***
- Any screen which allows ***closed paths*** leads to $A[\mu] < A[\mu]$ for any minimar surface μ along the screen and is therefore inconsistent.
- As a result, holographic screens are ***forbidden from crossing any null congruence*** emanating from X.
- This allows us to systematically catalogue all consistent screen trajectories of arbitrary signature.



Holographic screen sequestration

- It was proven in [3] that apparent horizons and trapped surfaces must lie behind event horizons. Holographic screens are therefore censored from both boundaries in a two-boundary spacetime.
- This supports the claim that ***screens of arbitrary signature have information content*** as both X and μ are inaccessible via local operations and classical communication between $\mathcal{B}$ and $\mathcal{B}'$.
- Further, we show that holographic screens are ***either entirely contained in or excluded from*** the wedge of X homologous to a given boundary.



Discussion and Outlook

- We can think of the HRT surface X as forcing the theory dual to the screen to remain within a fixed Hilbert space, the one associated to the homologous boundary. Screen sequestration therefore suggests that holographic theories themselves live on screens.
- How can we apply this to studying a timelike coarse-grained entropy? Is an Engelhardt-Wall construction available for timelike screens?
- What happens in multiboundary spacetimes? Can we apply the same technique to cosmologies where minimax surfaces are prevalent?
- So far we have only considered classical geometries with no backreaction. Does this still hold for e.g. evaporating singularities?

References:
[1] N. Engelhardt and A. C. Wall, *Coarse Graining Holographic Black Holes*, JHEP 05 (2019)
[2] R. Bousso and N. Engelhardt, *New Area Law in General Relativity*, Phys. Rev. Lett. 115, 081301 (2015)
[3] N. Engelhardt and Å. Folkestad, *Holography abhors visible trapped surfaces*, JHEP 07 (2021)