Rindler Quantum Gravity

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Motivations:

How does AdS/CFT work?

-How/why does spacetime emerge?

-How/why does gravity emerge?

Can we extend to more general spacetimes, e.g. cosmological?

Usual story:

vacuum state
of CFT on S^d

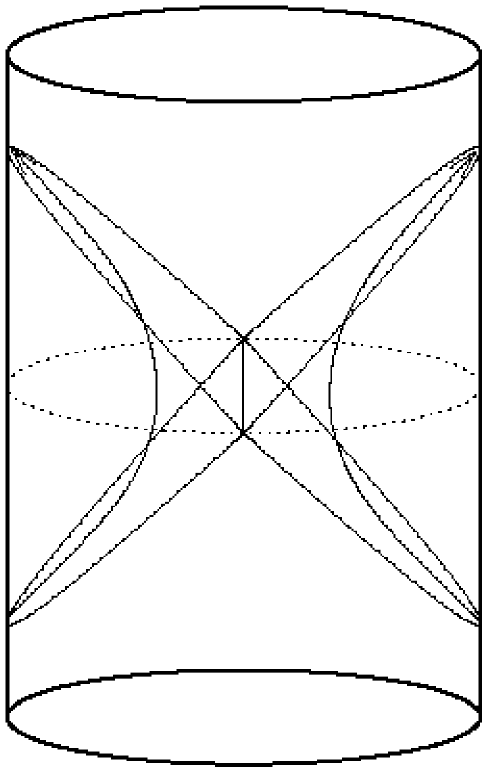
$$|0\rangle_{S^d}$$

An alternate description:

Entangled state of pair of H^d CFTs

$$\left|\Psi\right\rangle = \sum_i e^{-\pi R_H E_i} \left|E_i\right\rangle_{H^d} \otimes \left|E_i\right\rangle_{H^d}$$

An alternate description:

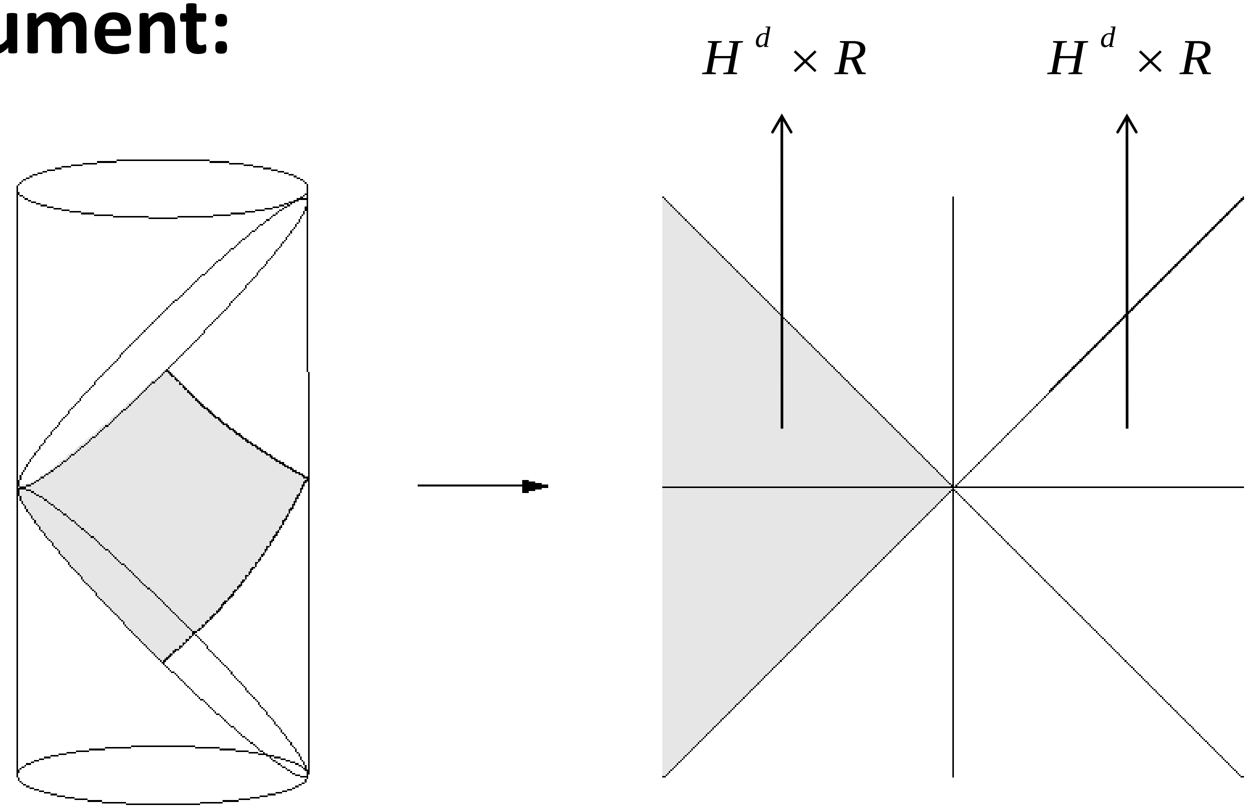


Entangled state of pair of H^d CFTs

$$\left|\Psi\right\rangle = \sum_i e^{-\pi R_H E_i} \left|E_i\right\rangle_{H^d} \otimes \left|E_i\right\rangle_{H^d}$$

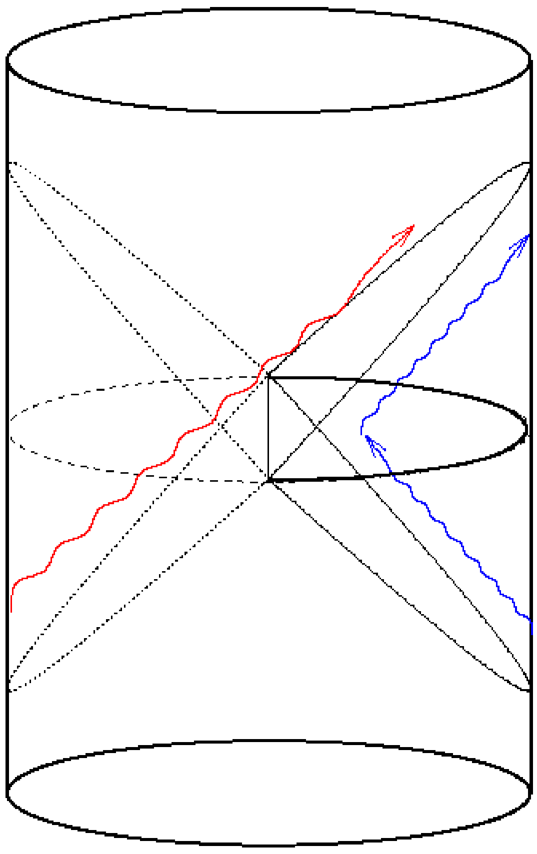
"Rindler" description of pure global AdS

Argument:



$$\left|0\right\rangle_{S^d} \leftrightarrow \left|0\right\rangle_{R^d} \leftrightarrow \sum_i e^{-\beta E_i/2}\left|E_i\right\rangle_{Rind} \otimes \left|E_i\right\rangle_{Rind} \leftrightarrow \sum_i e^{-\pi R_H E_i}\left|E_i\right\rangle_{H^d} \otimes \left|E_i\right\rangle_{H^d}$$

Single CFT picture:



Each H^d CFT in thermal state

$1/T = 2\pi R_H$ (Casini, Huerta, Myers)

$$\rho = \sum_i e^{-2\pi R_H E_i} \left| E_i \right\rangle \otimes \left\langle E_i \right|$$

Dual to ``hyperbolic black hole"

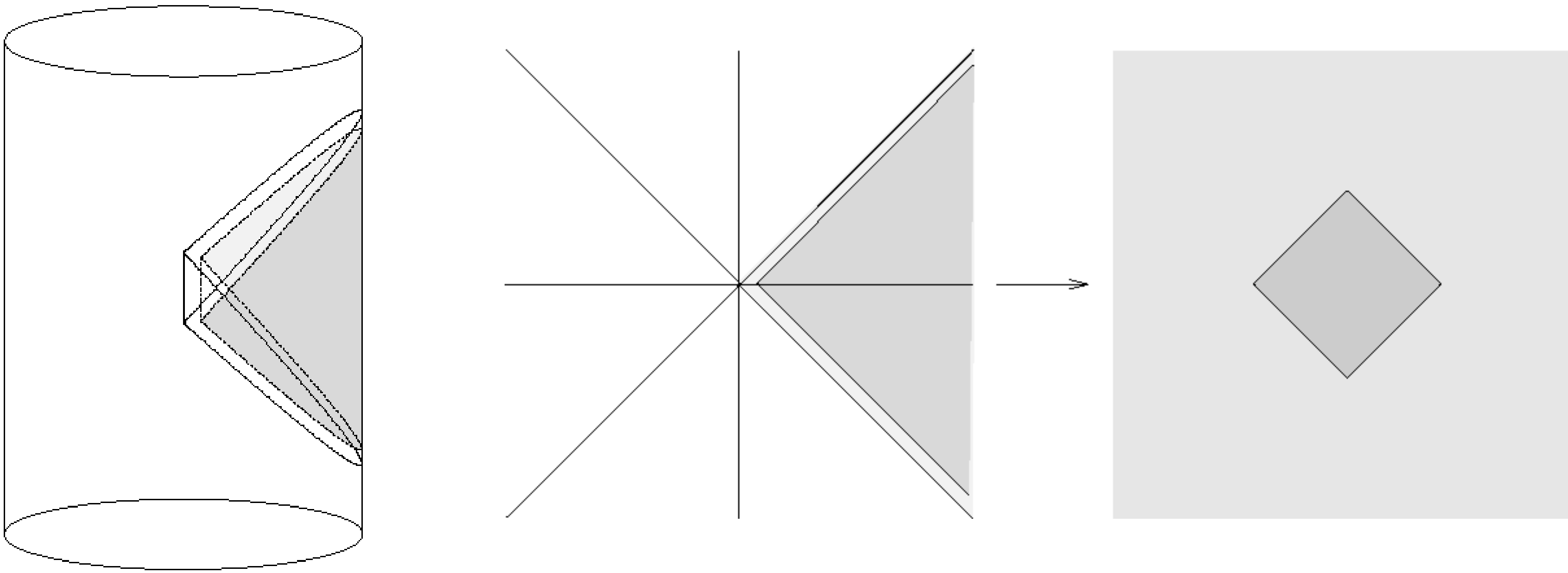
= wedge of pure AdS

= region accessible to accelerated observer

No information about geometry behind the horizon

"Microstates" of pure AdS

How do we interpret typical state $|E_i\rangle$ in ensemble ρ?

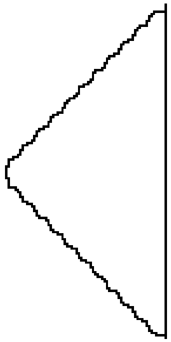


Density matrix for smaller region almost identical for $|E_i\rangle$ or ρ : dual to smaller wedge of pure AdS

But: pure state implies divergent $T^{\mu\nu}$ on Rindler horizon

$\rightarrow$ bulk horizon replaced by something singular

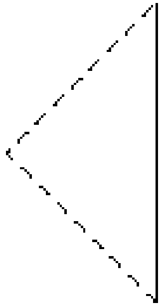
Different descriptions of a hyperbolic black hole



$|E_i\rangle$

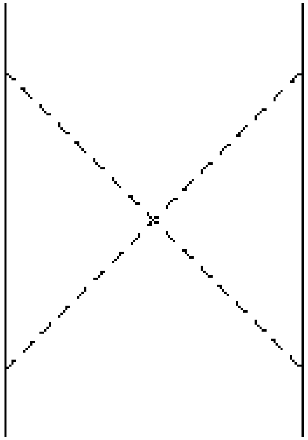
Microstate: wedge of pure AdS with "singular" edge (~ Mathur fuzzball)

Thermal state: wedge of pure AdS with horizon.



ρ

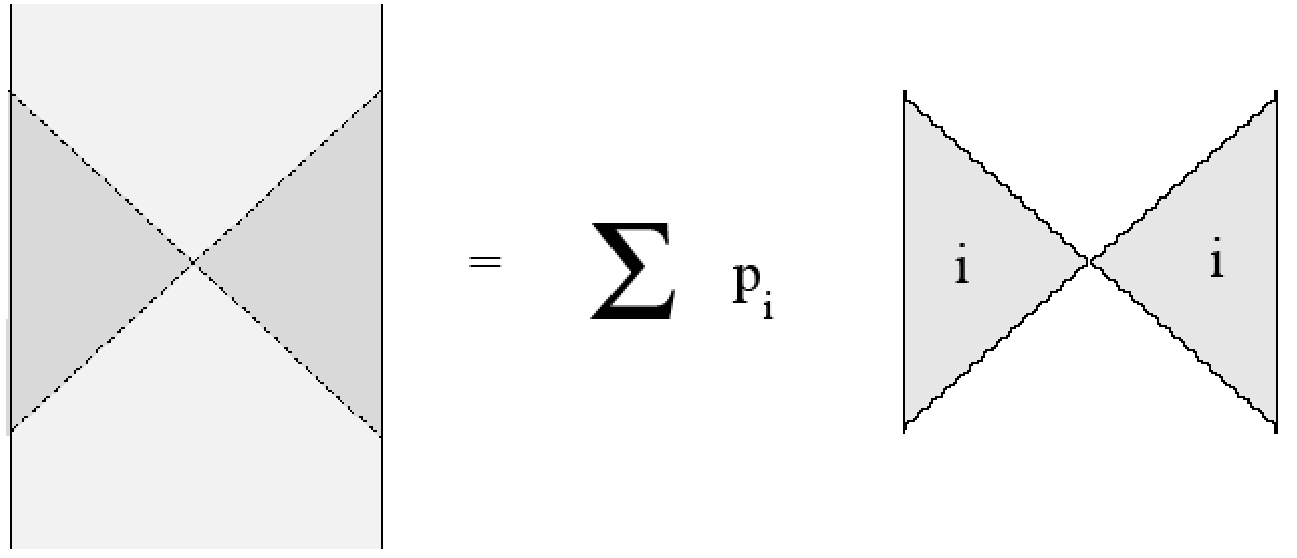
Different purifications = different spacetimes with this wedge



$$\sum_i e^{-\pi R_H E_i} |E_i\rangle \otimes |E_i\rangle$$

Entangled state of 2 CFTs: canonical extended spacetime: information behind horizons = entanglement information

Decomposing spacetime (cf MVR09, Mathur)

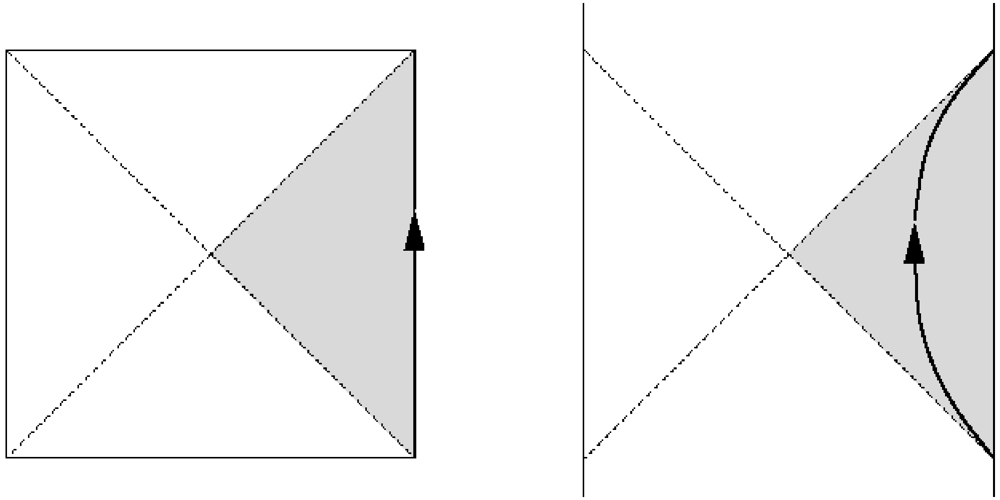


Pure AdS = quantum superposition of disconnected Rindler wedge microstates (explicit realization of Mathur proposal)

These are the microstates counted by Rindler horizon area

Choice of wedges arbitrary: -observer-dependent horizon area
-gives observer-dependent entropy
-counts observer-dependent microstates

Lessons for cosmological spacetimes?



Wild extrapolation to dS suggests:

- dS static patch described by density matrix for some degrees of freedom (different for different observers)
- dS entropy best viewed as entanglement entropy (microstates like static patch with horizon replaced by end of spacetime, but physical spacetime NOT a microstate)

Differences: need finite number of d.o.f., different dynamics

Emergence of spacetime via entanglement

Have seen: connected spacetimes emerge when subsets of degrees of freedom (maximally) entangled

Approximations to ground state incorporating entanglement at successively longer scales correspond to (t=0) spacetimes that extend further and further to IR

Emergence of spacetime (dynamical)

Field theory evolution: subsystems maximize entanglement for given energy

Starting with atypical high-energy state, density matrix for successively larger subsystems approach thermal

Classical spacetime grows from UV $\longrightarrow$ IR