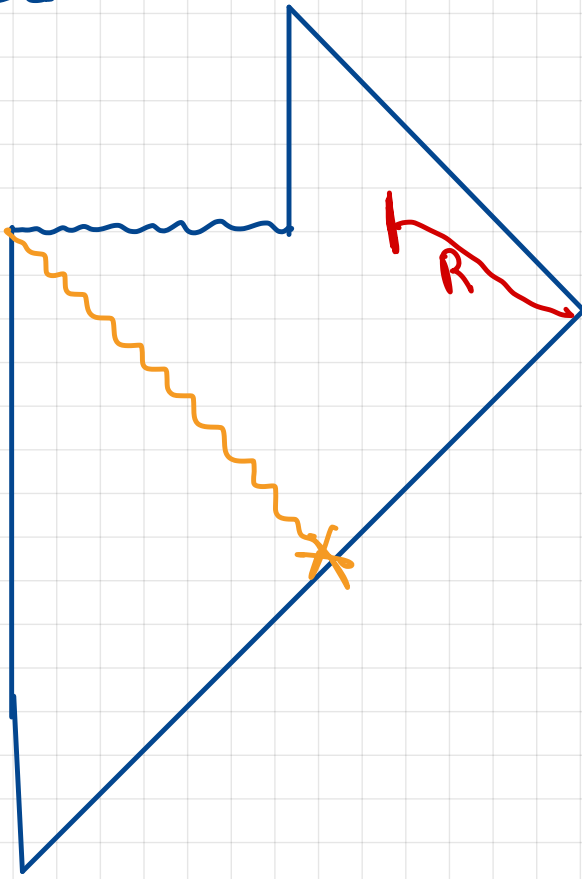


20.

Replica

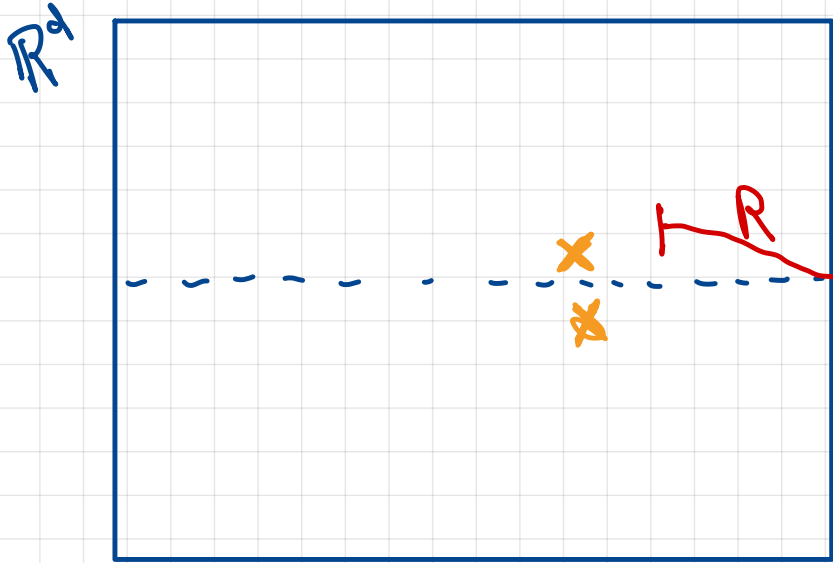
Wormholes

Lorentzian

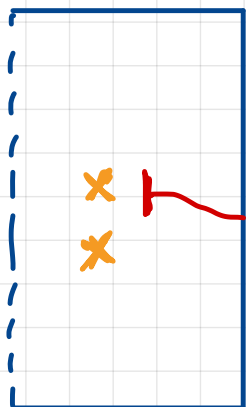


S(PR)

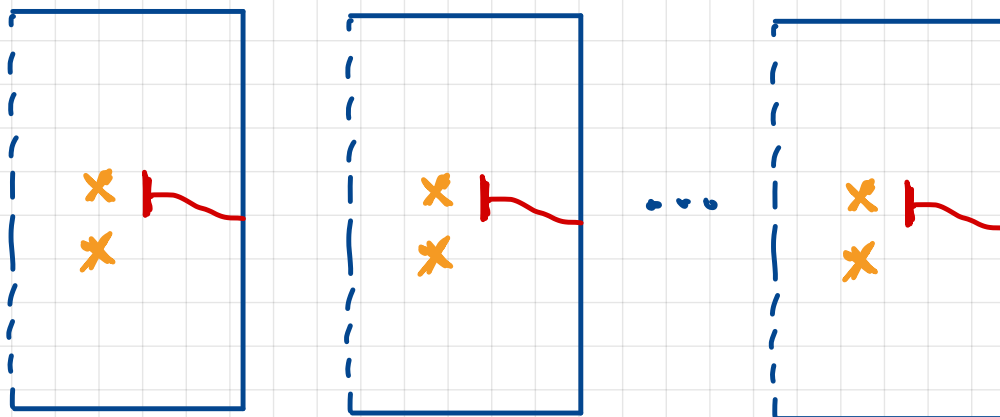
Euclidean



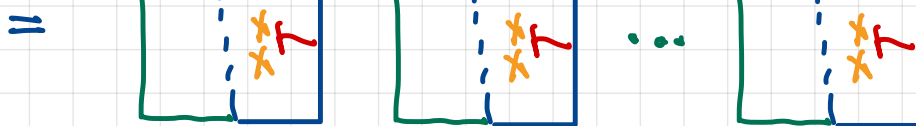
$\mathcal{P}_R = \text{gravity P.I. w/ boundary condition}$



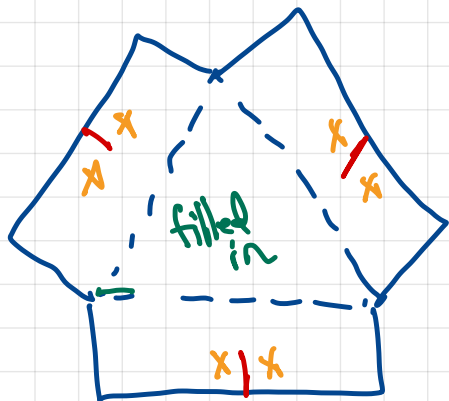
$\text{Tr} \mathcal{P}_R^n =$



$\sum_{\text{topologies}}$

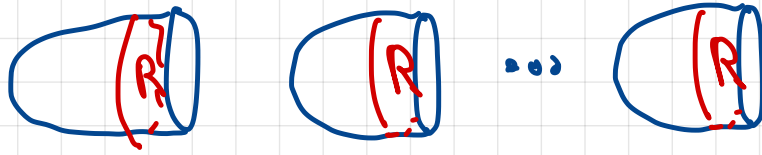


+

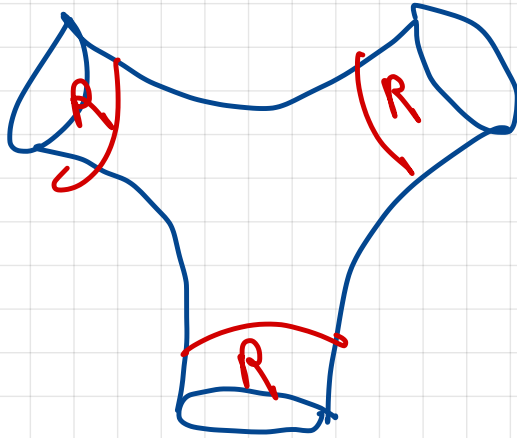


+ ...

Spatial slices:

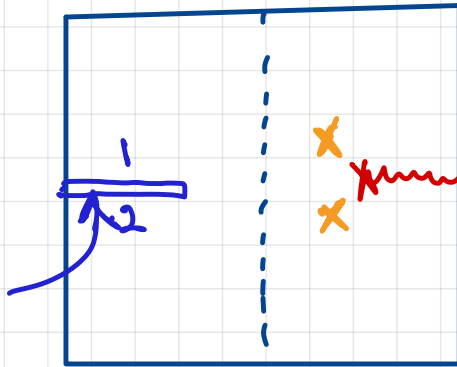


+



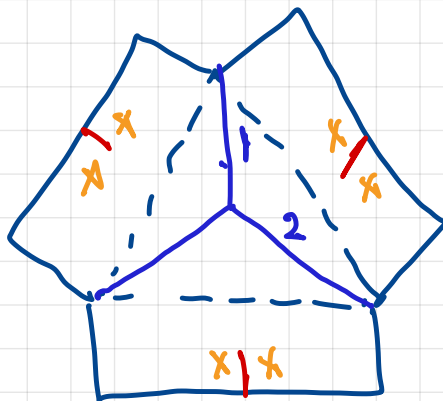
"Replica Wormhole"

RWH topology \equiv



New branch cut!

IE:



Thus

$$\text{Tr} P_R^{-1} = \left[\text{square} \right]_{\otimes n} + \left[\text{square} \right]_{\otimes n} + \dots$$

The first square contains a red squiggly line. The second square contains a blue squiggly line and a red squiggly line.

Take $n \approx 1$

\Rightarrow

$$e^{-(n-1)S(P_R)} \approx e^{-(n-1)S(P_R^{\text{Hawking}})} + \int d(\text{location of } I) e^{-(n-1)\left[\frac{1}{4}\text{area}(I) + S(\tilde{P}_{I, \text{ext}})\right]}$$

$$S(P_R) \approx \min \left\{ \begin{array}{l} S(P_R^{\text{Hawking}}) \\ \frac{1}{4}\text{Area}(I) + S(\tilde{P}_{I, \text{ext}}) @ \text{extremum} \end{array} \right.$$

CAVEATS !

- AdS
- Instabilities of flat space
- Boundary fixing