Title: Superselection Sectors in AdS/CFT - Joint Quantum Gravity and String Theory Seminar

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Abstract: AdS/CFT is a duality
relating the degrees of freedom in a D dimensional bulk gravity theory to a (D-1) dimensional theory living on the boundary. I will argue that in fact the boundary theory contains only a subset of the bulk observables. For each state of the boundary theory, there are multiple bulk states dual to it, which can be operationally distinguished by observers who fall across event horizons. Based on arXiv:1210.3590.

ARON WALL

Superselection Sectors in AdS/CFT

arXiv: 1210.3590 (Don Marolf & me)

See also 0810.4886, 0808.2842 (just Don)

+ earlier papers by Ted Jacobson, Lee...

FT

AdS/CFT is duality $\begin{cases} \text{bulk quantum g. theory w/ } n \text{ asy. AdS regions} \\ n \text{ copies of CFT} \end{cases}$

in AdS/CFT

& me)

on)

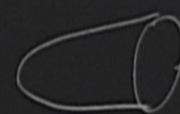
...

AdS/CFT is duality $\begin{cases} \text{bulk quantum g. theory w/ } n \text{ asy. AdS region} \\ n \text{ copies of CFT} \end{cases}$

different bul[k] stat[e]

What if this duality is incomplete

$\text{bulk}_1 = \text{CFT} \times S_1$

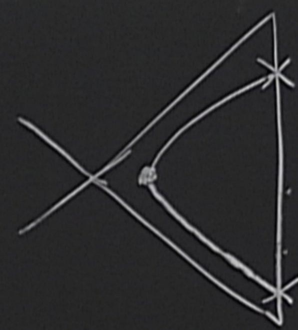


$\text{bulk}_2 = \text{CFT} \times \text{CFT} \times S_2$

$\text{bulk}_n = \text{CFT}^n \times S_n$

AdS regions

different bulk states $\longrightarrow$ same boundary



1) Because T_{ab} is a CFT operator

S_n carries no energy or momentum

$\longrightarrow$ invariant under each AdS group

CFT

2) all superselection info hidden behind a past OR a future horizon

ONE BOUNDARY

CFT ~ $\overline{\text{bulk}}$ ⊂ bulk, be one particular sector
w/ connected asy. AdS spacetimes

= CFT

∞ amount of info

finite # states < E

Sectors in AdS/CFT

(Don Marolf & me)

...a2 (just Don)

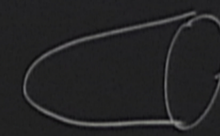
...son, Lee...

AdS/CFT is duality $\begin{cases} \text{bulk quantum g. theor...} \\ n \text{ copies of CF...} \end{cases}$

What if this duality is incomplete

$$\text{bulk}_0 = S_0$$

$$\text{bulk}_1 = \text{CFT} \times S_1$$

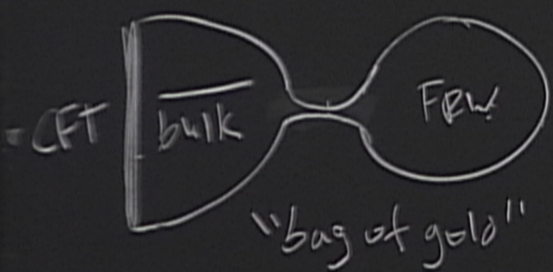


$$\text{bulk}_2 = \text{CFT} \times \text{CFT} \times S_2$$

$$\text{bulk}_n = \text{CFT}^n \times S_n$$

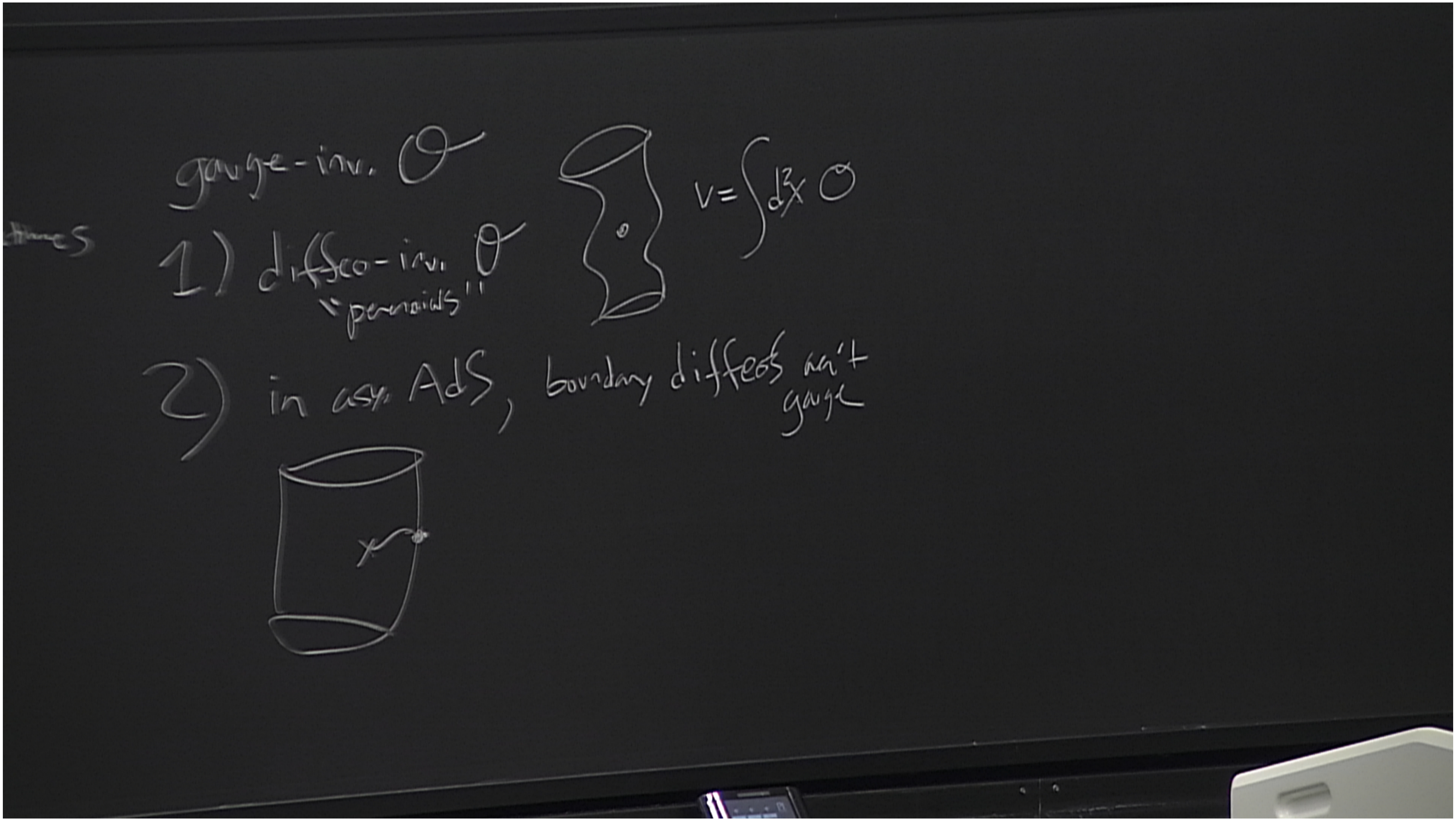
ONE BOUNDARY

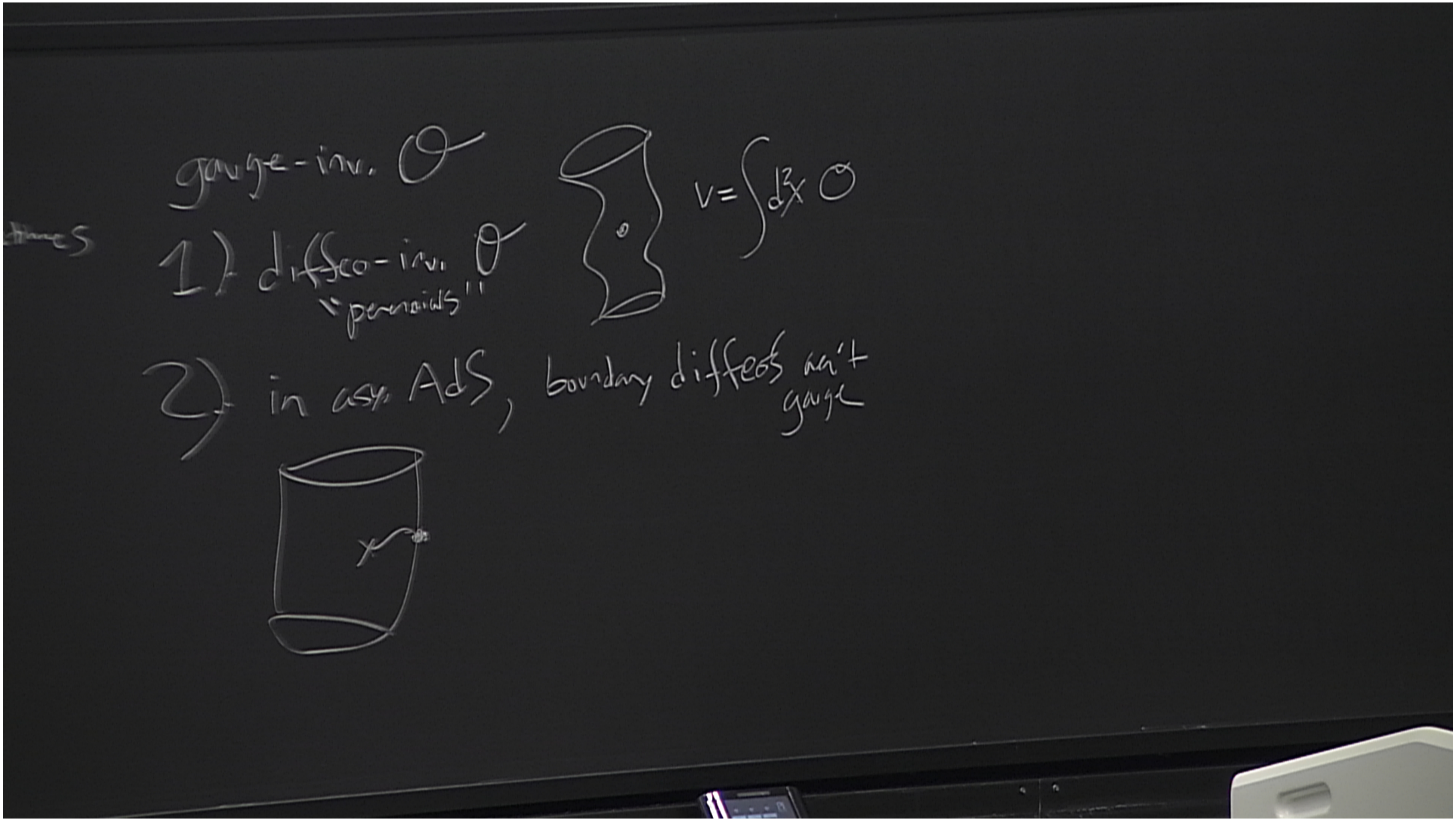
CFT $\sim \overline{\text{bulk}} \subset$ bulk, be one particular sector
w/ connected asy. AdS spacetimes

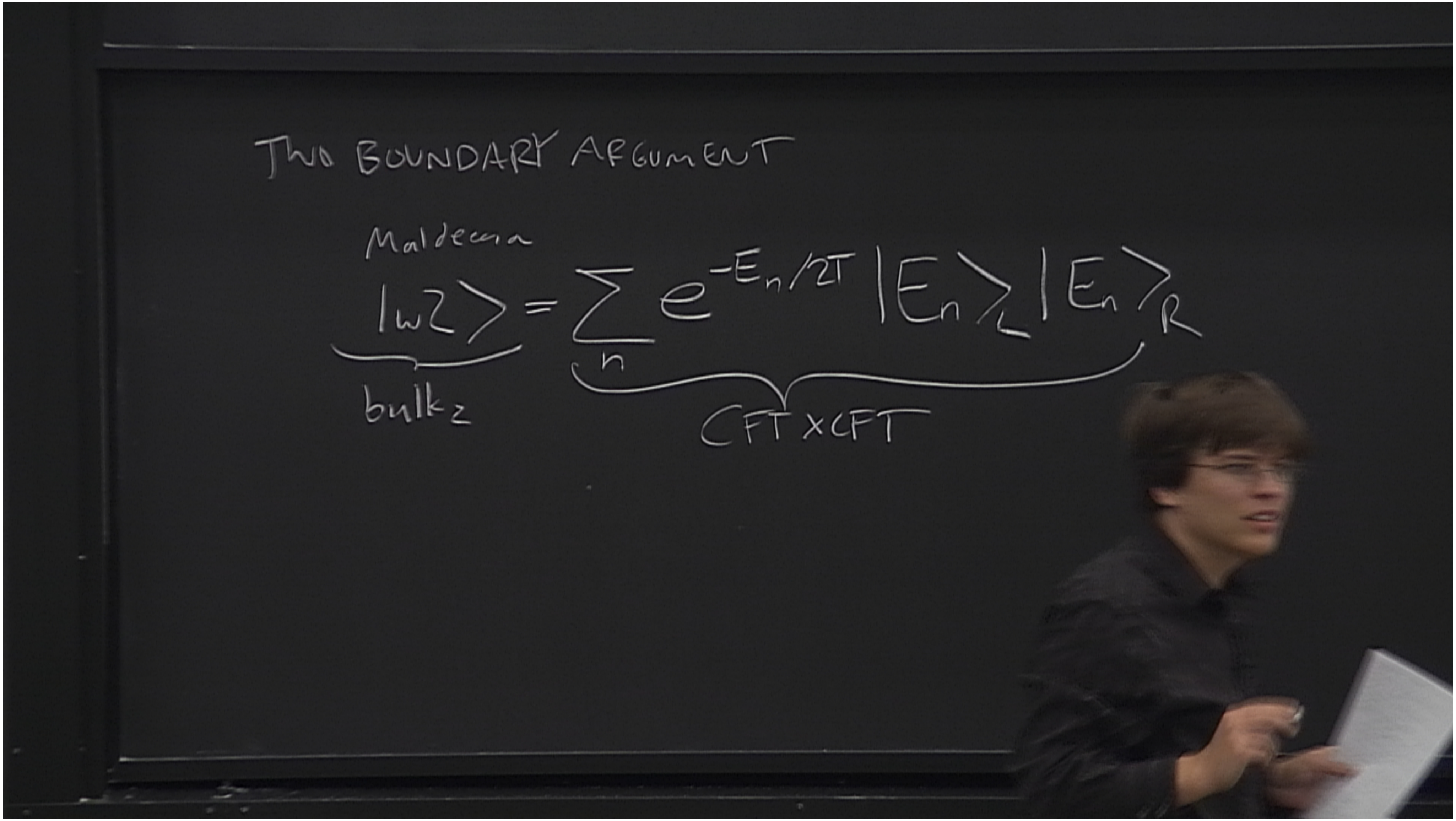


∞ amount of info

finite # states $< E$


gauge-inv. O
1) diffeo-inv. O
V = ∫d²x O
2) in asy. AdS, boundary diffeos aren't gauge

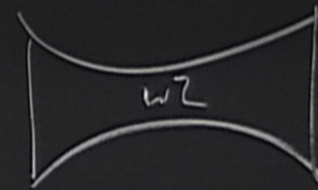

gauge-inv. $\mathcal{O}$
1) $\nexists$ diffeo-inv. $\mathcal{O}$
$V = \int d^2x\, \mathcal{O}$
2) in asy. AdS, boundary diffeos can't gauge


TWO BOUNDARY ARGUMENT
Maldecena
$\underbrace{|w2\rangle}_{\text{bulk}_2} = \underbrace{\sum_n e^{-E_n/2T} |E_n\rangle_L |E_n\rangle_R}_{CFT \times CFT}$

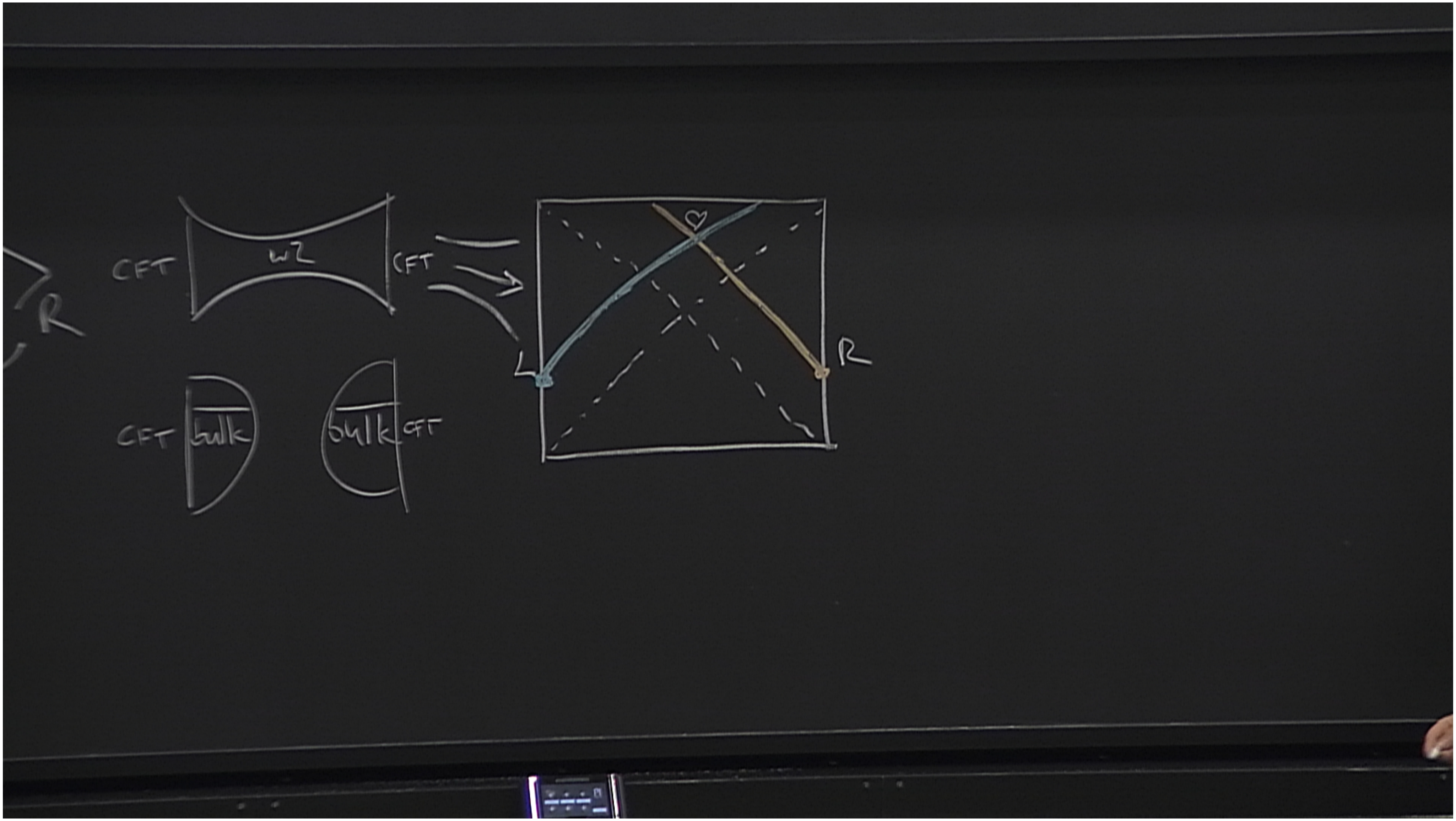
TWO BOUNDARY ARGUMENT

Maldecena

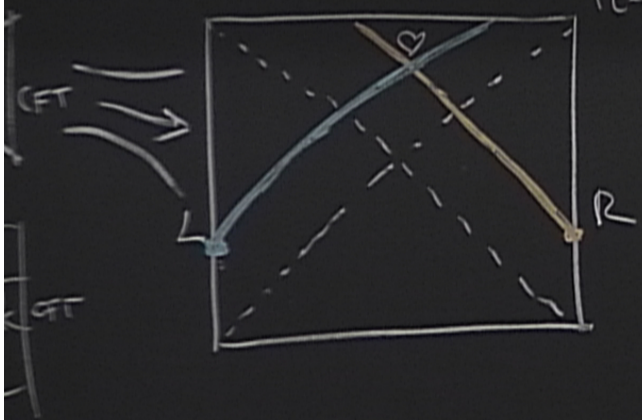
$$\underbrace{|WZ\rangle}_{\text{bulk}_2} = \underbrace{\sum_n e^{-E_n/2T} |E_n\rangle_L |E_n\rangle_R}_{CFT \times CFT}$$



$$\underset{\text{bulk}_2}{|TFD\rangle} = \underline{\text{bulk}} \otimes \underline{\text{bulk}}$$


R
CFT
wZ
CFT
CFT
bulk
bulk
CFT
L
R

$x > h$

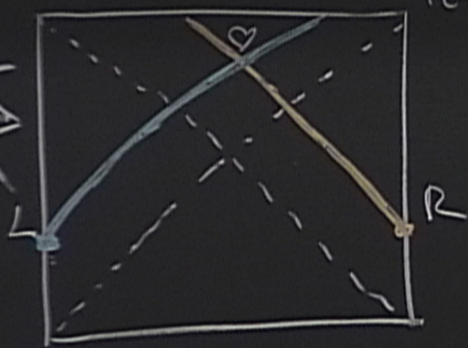


let e^{iA} be a unitary in CFT_R which creates Alice when acting on $|w2\rangle$

e^{iB} // CFT_L // Bob //

P is a projection: Does this Alice meet <u>a</u> Bob.

$X > h$



let e^{iA} be a unitary in CFT_R which creates Alice when acting on $|W\rangle$

e^{iB} // CFT_L // Bob //

P is a projection: Does this Alice meet a Bob

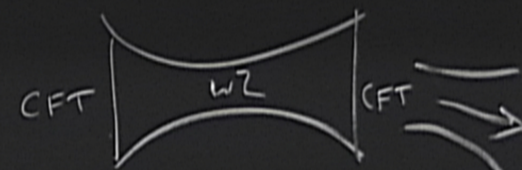
$\langle W| e^{-i(A+B)} P e^{i(A+B)} |W\rangle \approx 1 \leftarrow$ semiclassical approx.

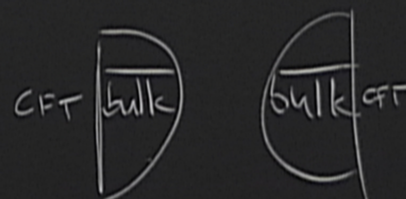
$\langle W| e^{-iA} P e^{iA} |W\rangle \approx 0$

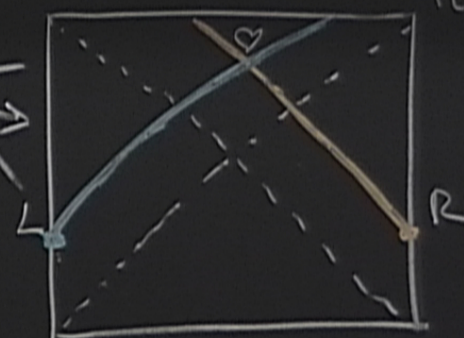
ARGUMENT

$$= \underbrace{\sum_n e^{-E_n/2T} |E_n\rangle_L |E_n\rangle_R}_{CFT \times CFT}$$

$$= \overline{\text{bulk}} \otimes \overline{\text{bulk}}$$







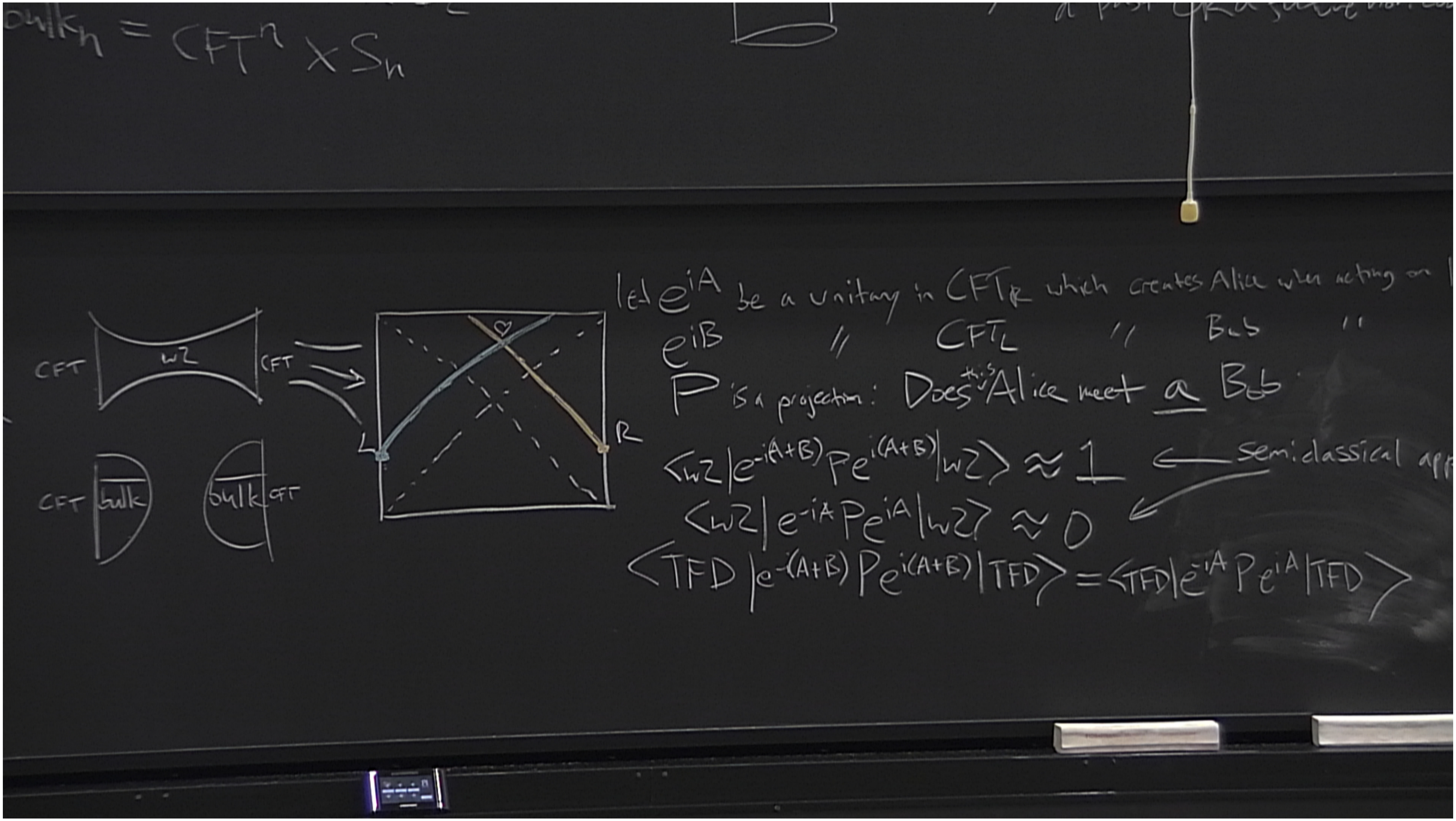
let e^{iA} be

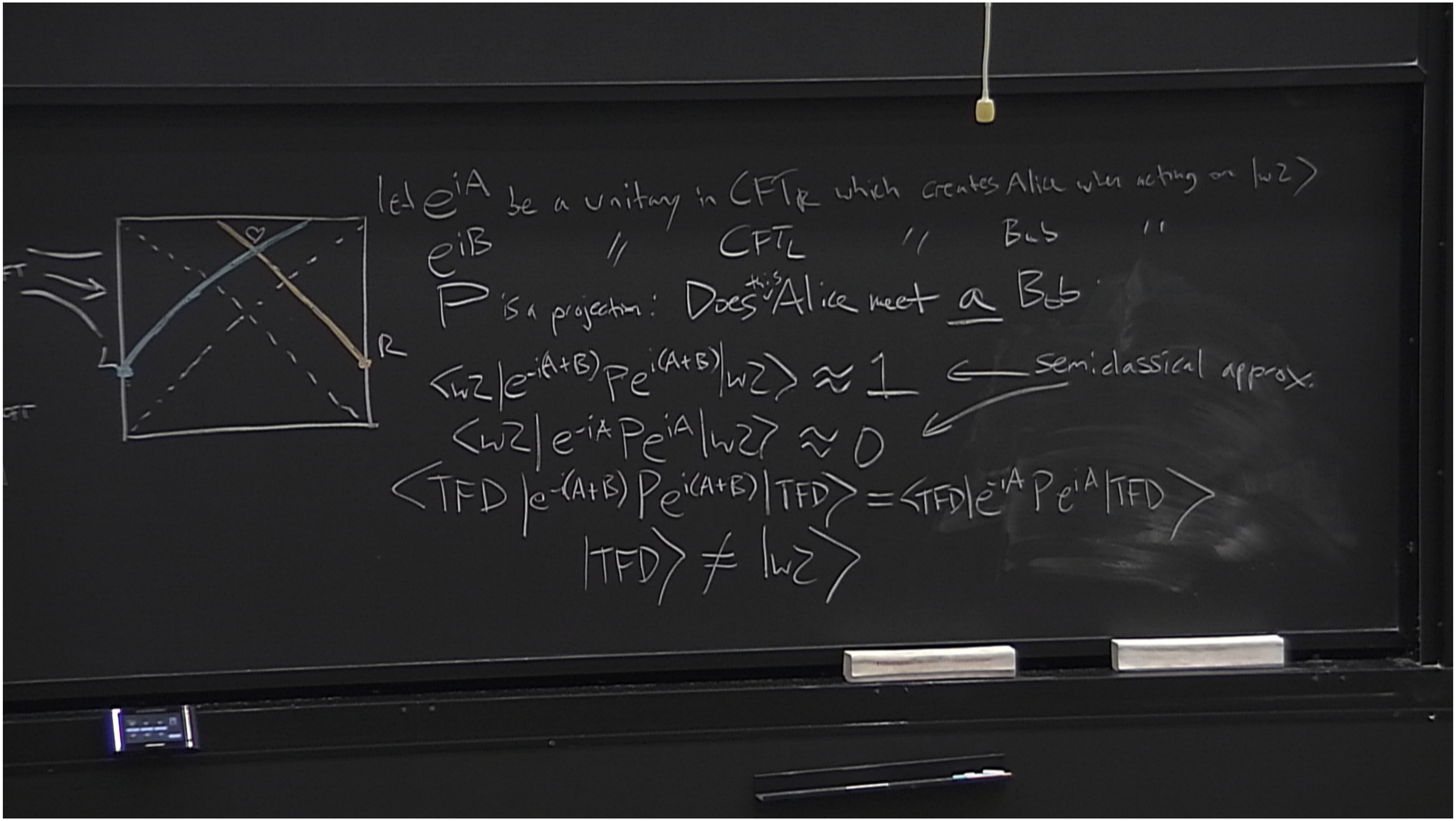
e^{iB}

P is a

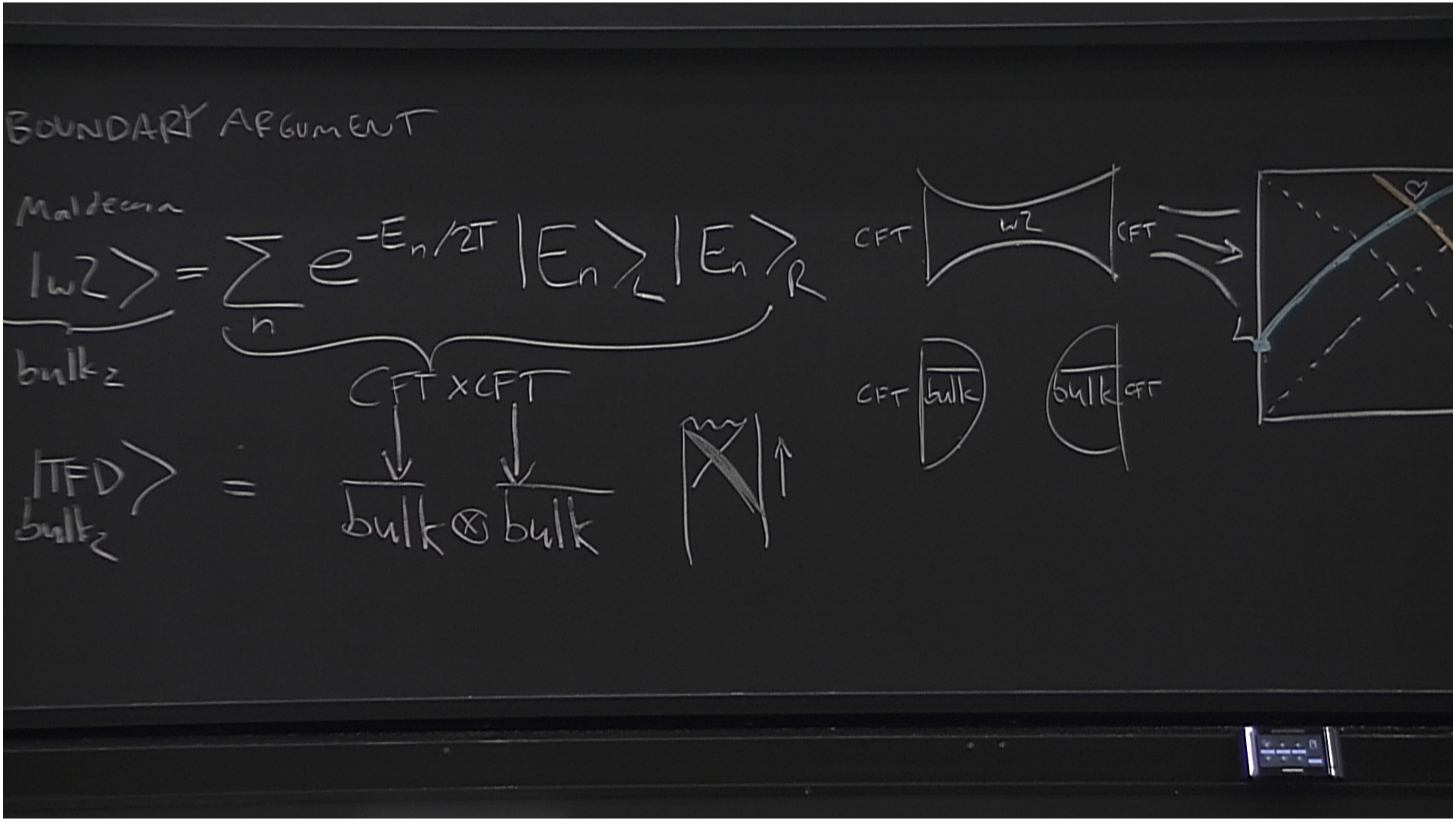
$\langle WZ| e^{-i}$

$\langle WZ|$


bulk_n = CFT^n × S_n
CFT
WZ
CFT
L
R
CFT
bulk
bulk
CFT
let e^{iA} be a unitary in CFT_R which creates Alice when acting on
e^{iB} // CFT_L // Bob //
P is a projection: Does this Alice meet a Bob
⟨WZ|e^{-i(A+B)} P e^{i(A+B)}|WZ⟩ ≈ 1 ← semi-classical app
⟨WZ|e^{-iA} P e^{iA}|WZ⟩ ≈ 0
⟨TFD|e^{-i(A+B)} P e^{i(A+B)}|TFD⟩ = ⟨TFD|e^{-iA} P e^{iA}|TFD⟩



let e^{iA} be a unitary in CFT_R which creates Alice when acting on $|WZ\rangle$
e^{iB} // CFT_L // Bob //
P is a projection: Does this Alice meet a Bob
$\langle WZ|e^{-i(A+B)} P e^{i(A+B)}|WZ\rangle \approx 1$ ← semiclassical approx.
$\langle WZ|e^{-iA} P e^{iA}|WZ\rangle \approx 0$
$\langle TFD|e^{-i(A+B)} P e^{i(A+B)}|TFD\rangle = \langle TFD|e^{-iA} P e^{iA}|TFD\rangle$
$|TFD\rangle \neq |WZ\rangle$
L
R



BOUNDARY ARGUMENT
Maldecena
|WZ> = Σ_n e^{-E_n/2T} |E_n>_L |E_n>_R
bulk_2
CFT x CFT
|TFD> = bulk ⊗ bulk
bulk_2
CFT
WZ
CFT
CFT
bulk
bulk
CFT