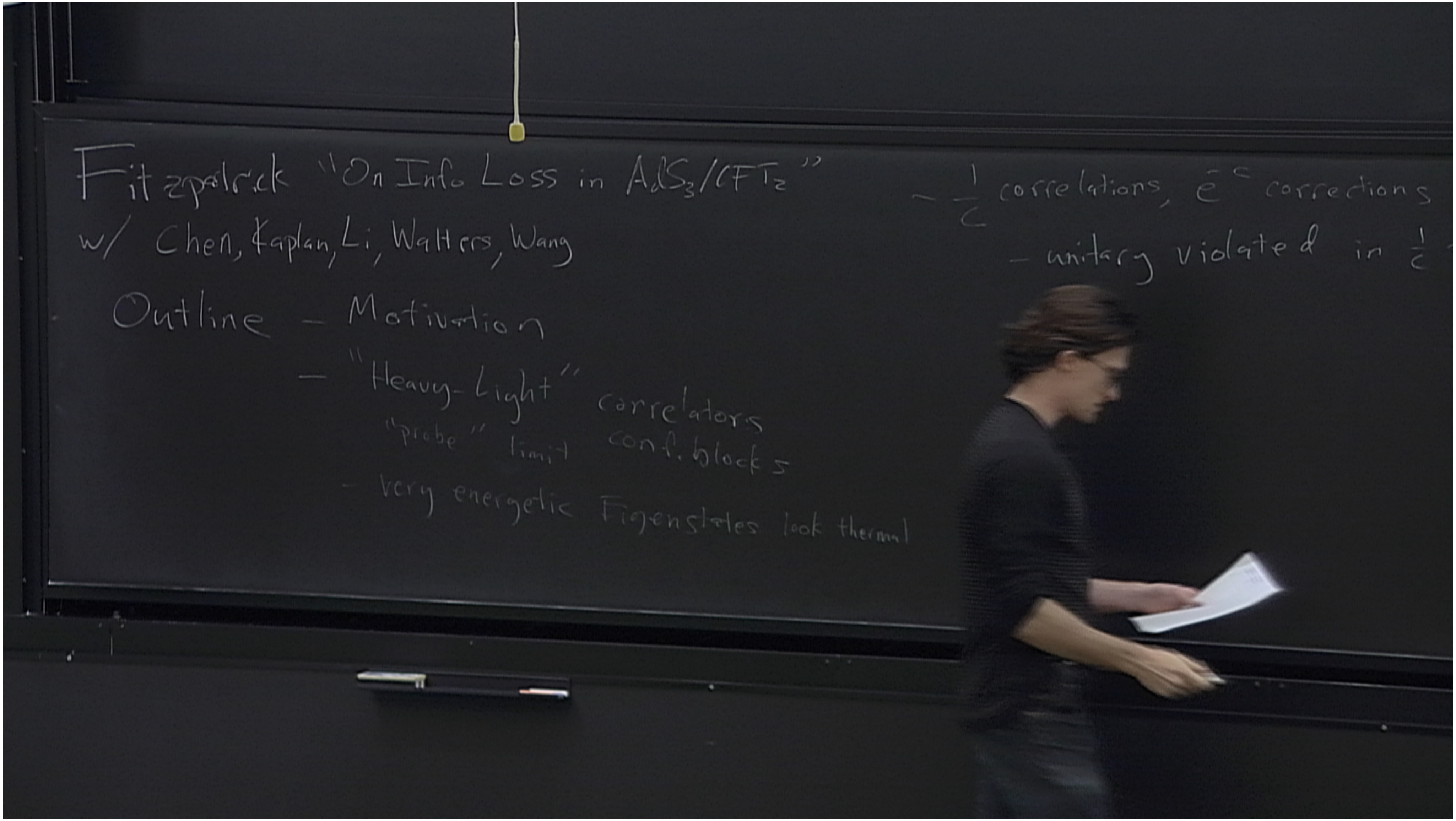
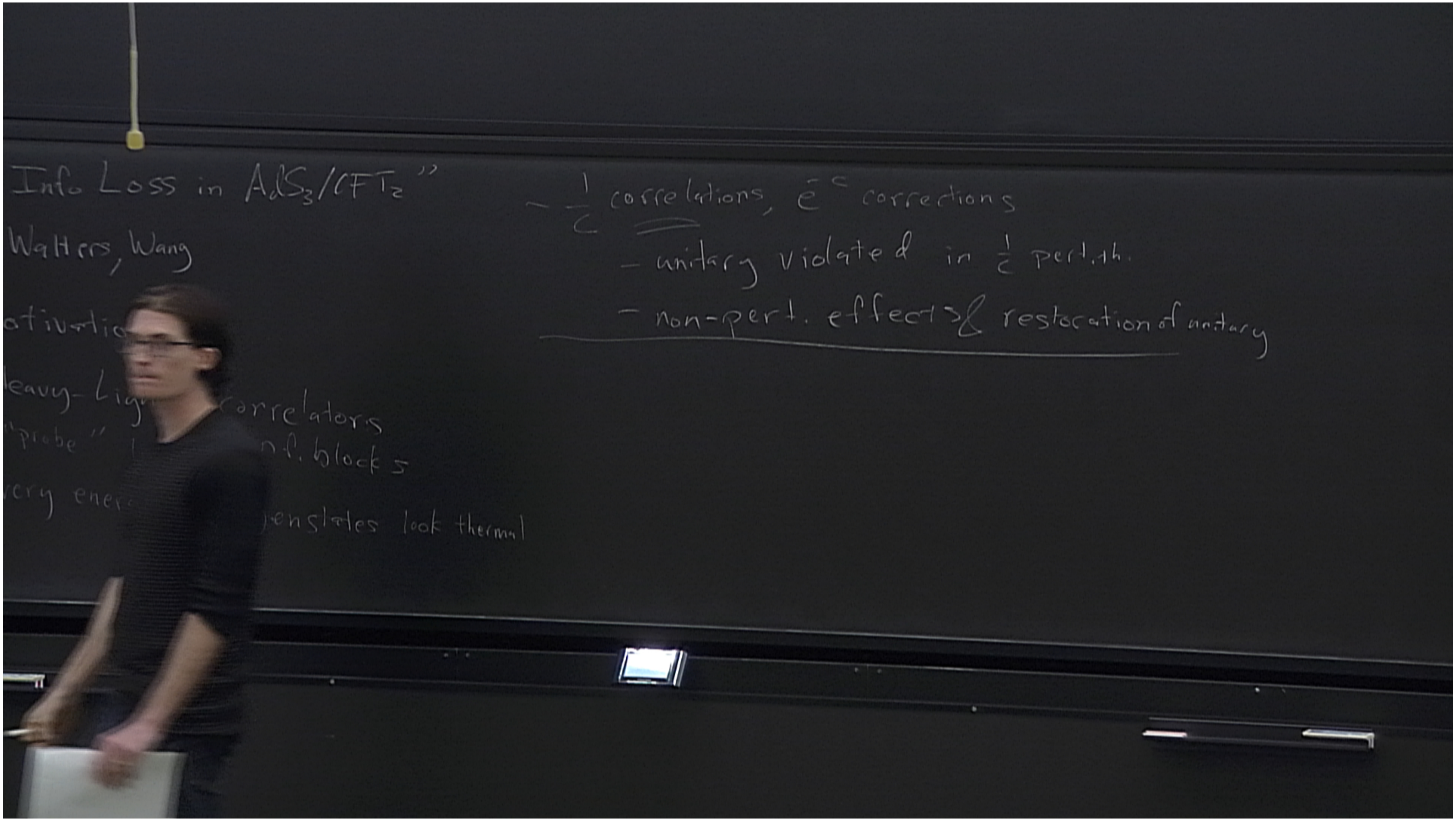
Title: On Information Loss in AdS3/CFT2

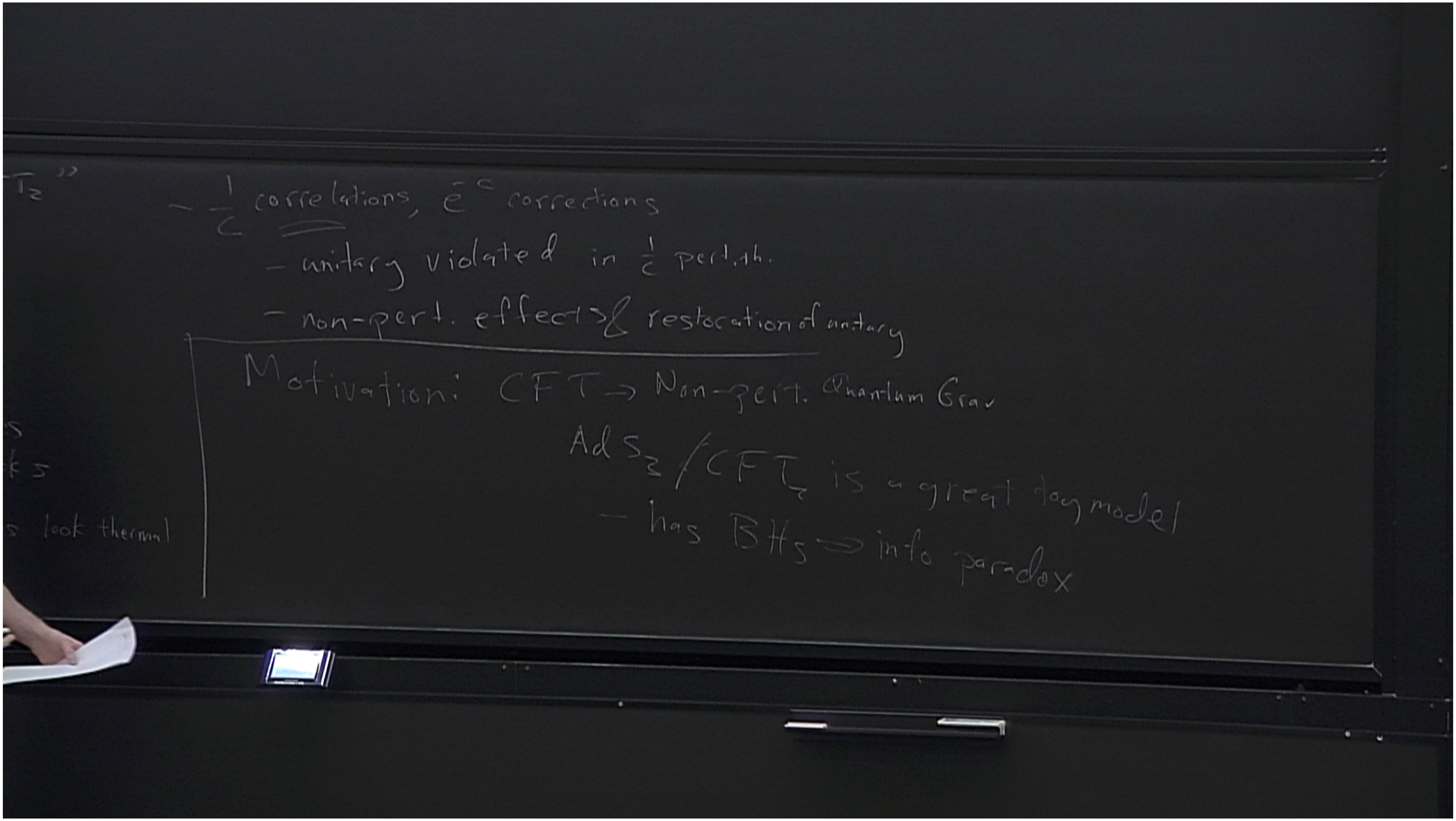
Date: Sep 27, 2016 02:00 PM

URL: http://pirsa.org/16090049

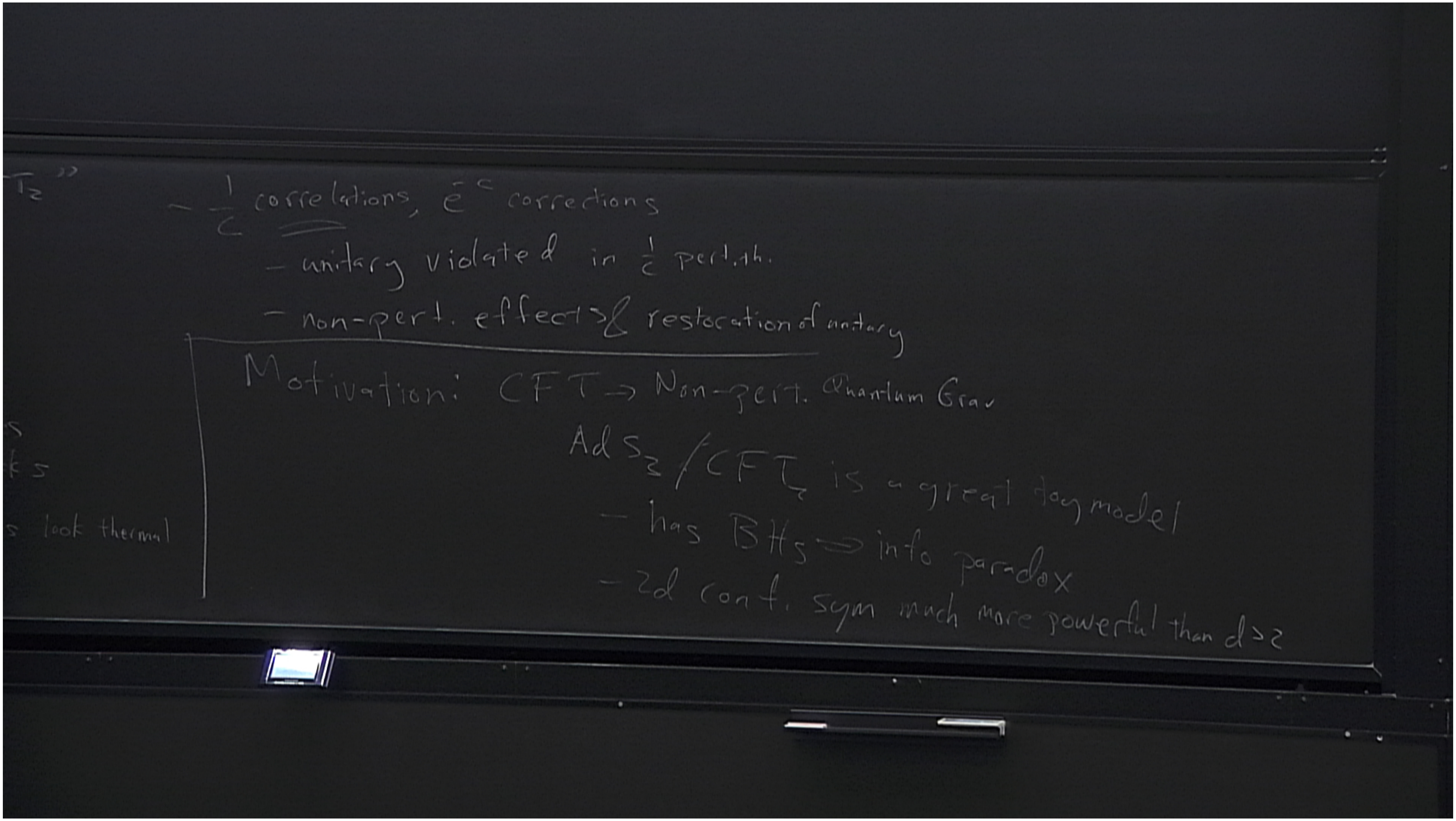
Abstract: <p>We discuss information loss from black hole physics in AdS3, focusing on two sharp signatures infecting CFT2 correlators at large central charge c: `forbidden singularities' arising from Euclidean-time periodicity due to the effective Hawking temperature, and late-time exponential decay in the Lorentzian region. We show that these signatures can be derived from the behavior of the Virasoro conformal blocks at large central charge. At finite c, we compute non-perturbative effects that resolve the unitarity-violation from forbidden singularities. Finally, we elaborate on the non-perturbative behavior of Virasoro blocks by classifying all `saddlesâ€™ that can contribute for arbitrary values of external and internal operator dimensions in the semiclassical large central charge limit, and discuss their potential to resolve the problem of late-time decay in the Lorentzian regime. </p>


Fitzpatrick "On Info Loss in AdS3/CFT2"
w/ Chen, Kaplan, Li, Walters, Wang
Outline – Motivation
– "Heavy-Light" correlators
"probe" limit conf. blocks
– very energetic Eigenstates look thermal
– 1/c correlations, e^-c corrections
– unitary violated in 1/c


"Info Loss in AdS3/CFT2"
Walters, Wang
correlations, corrections
- unitary violated in pert. th.
- non-pert. effects & restoration of unitary
correlators
blocks
look thermal



- 1/c correlations, e^{-c} corrections
- unitary violated in 1/c pert. th.
- non-pert. effects & restoration of unitary
Motivation: CFT → Non-pert. Quantum Grav
AdS_3/CFT_2 is a great toy model
- has BHs ⇒ info paradox
look thermal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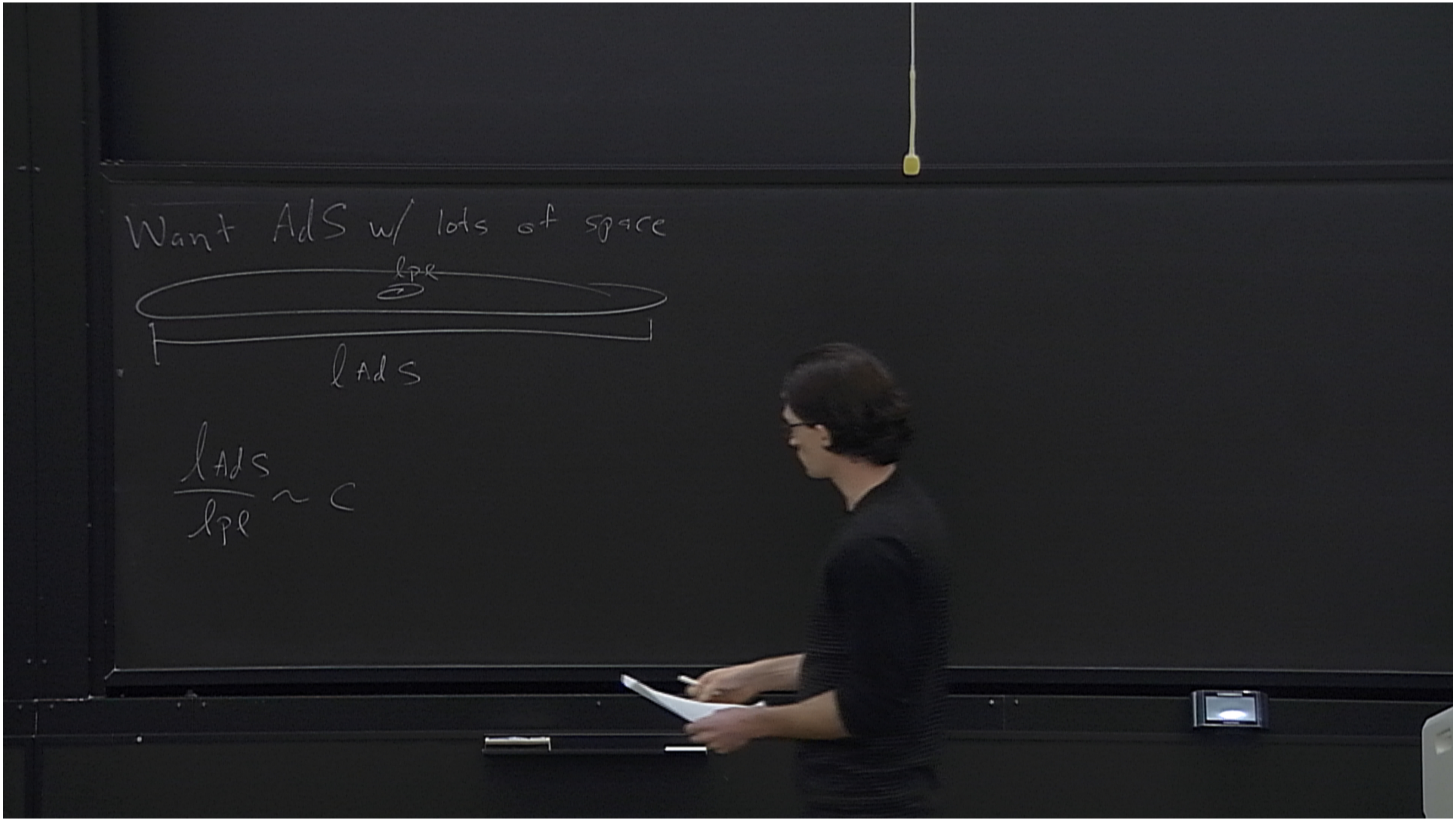
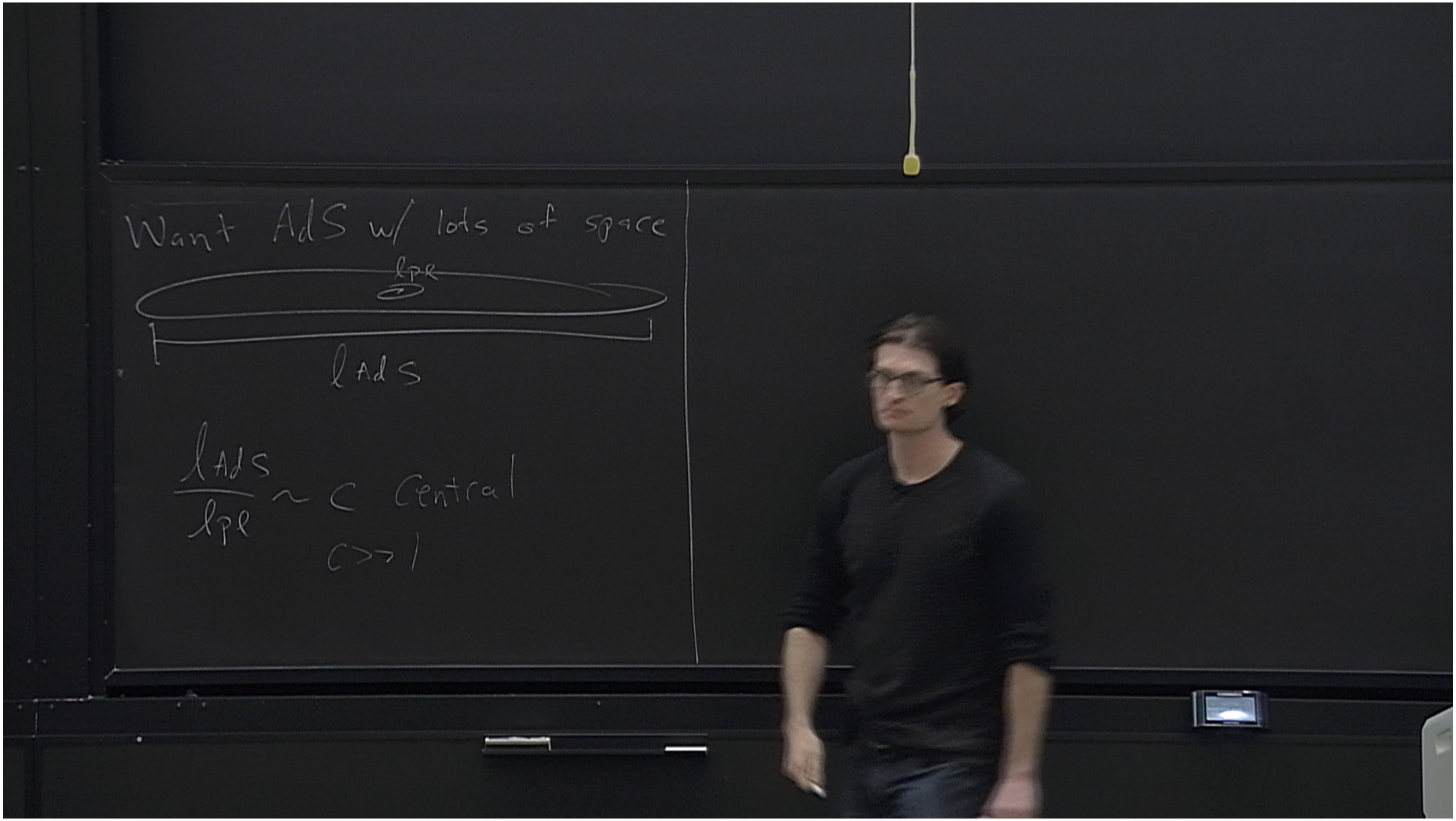
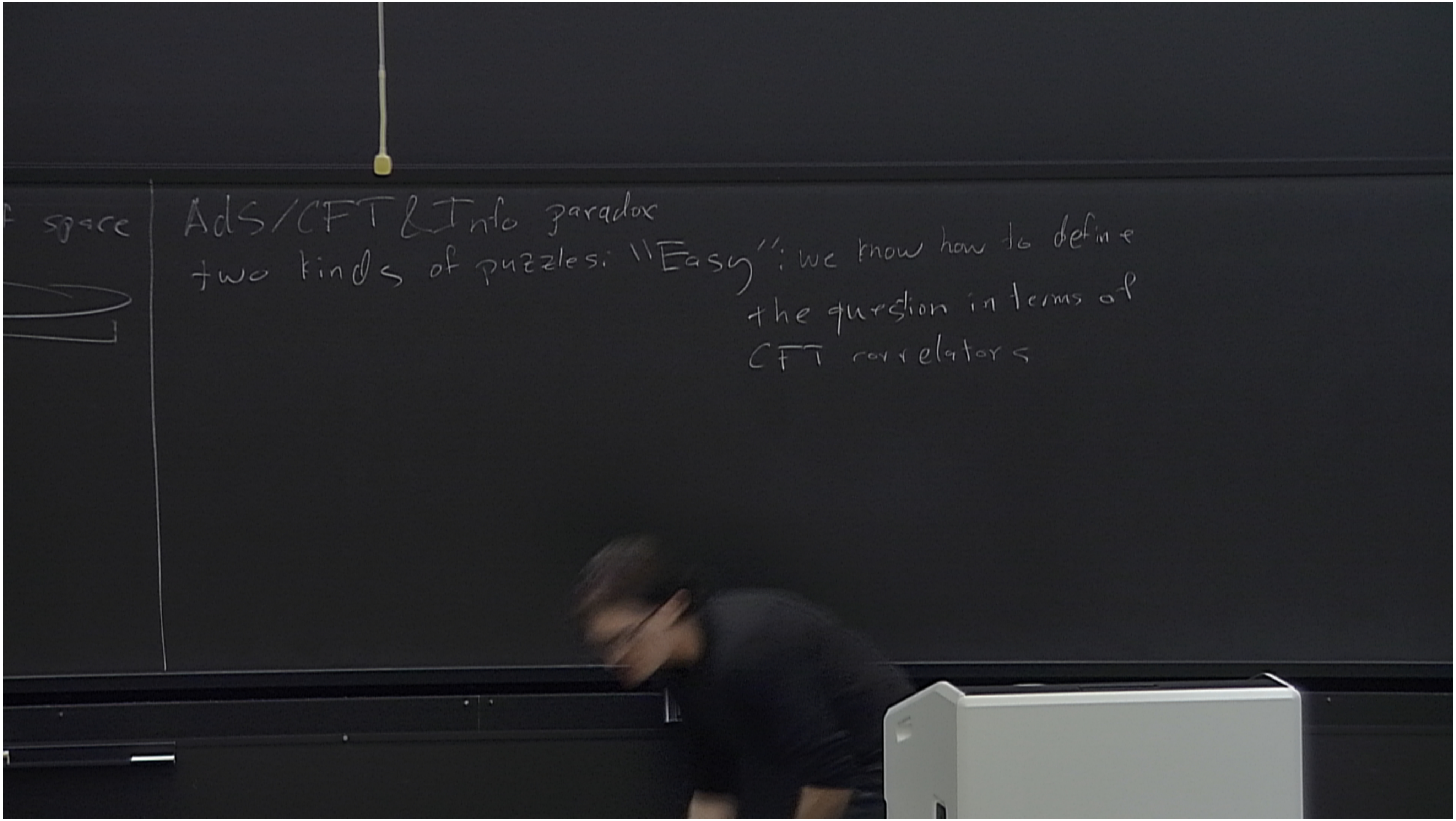
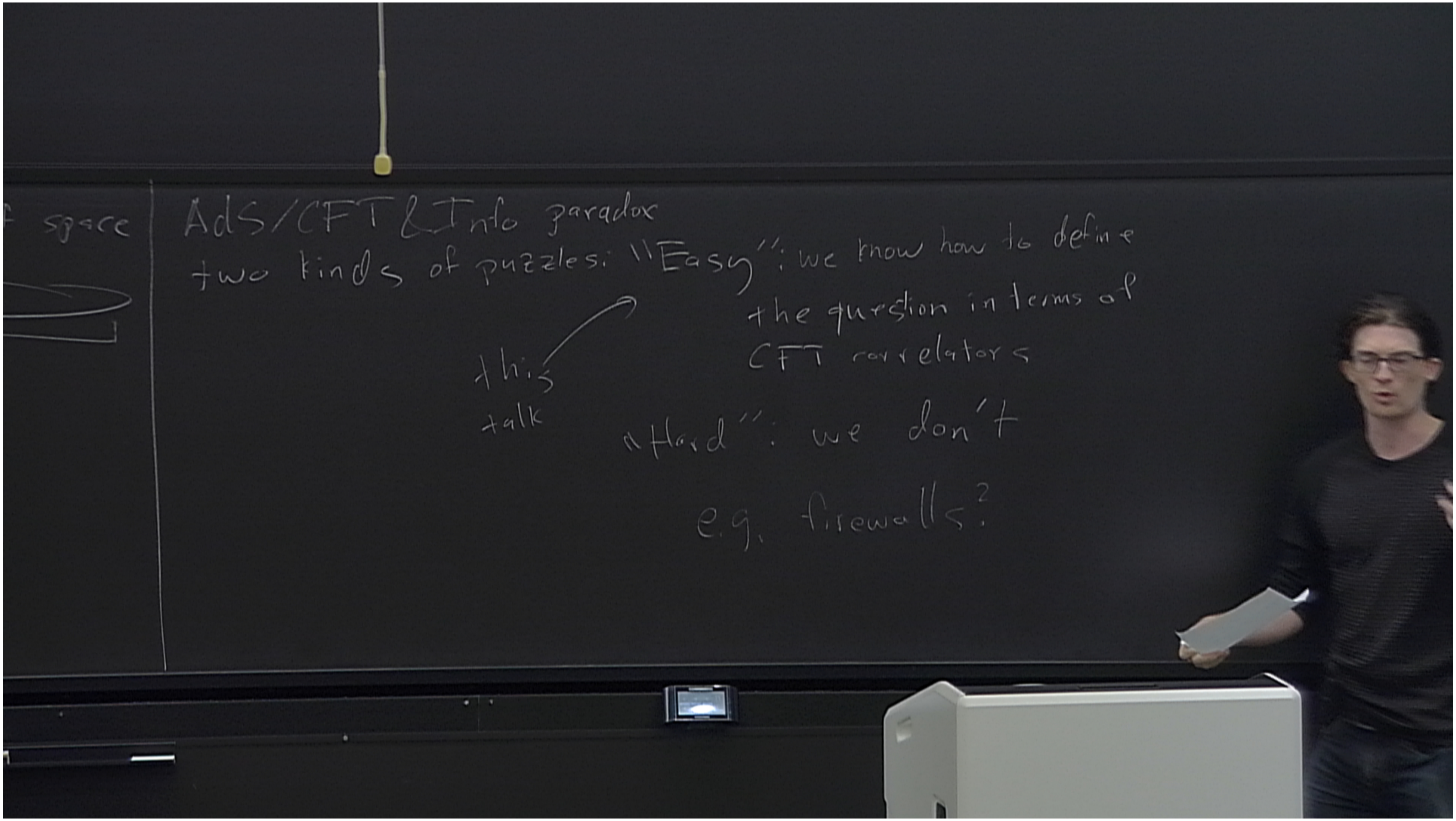
AdS3/CFT2 is a great toy model
– has BHs ⇒ info paradox
– 2d conf. sym much more powerful than d>2
look thermal


Want AdS w/ lots of space
lpl
l AdS
l AdS / lpl ~ c


Want AdS w/ lots of space
lpl
l AdS
l AdS / lpl ~ c central
c >> 1


space
AdS/CFT & Info paradox
two kinds of puzzles: "Easy": we know how to define
the question in terms of
CFT correlators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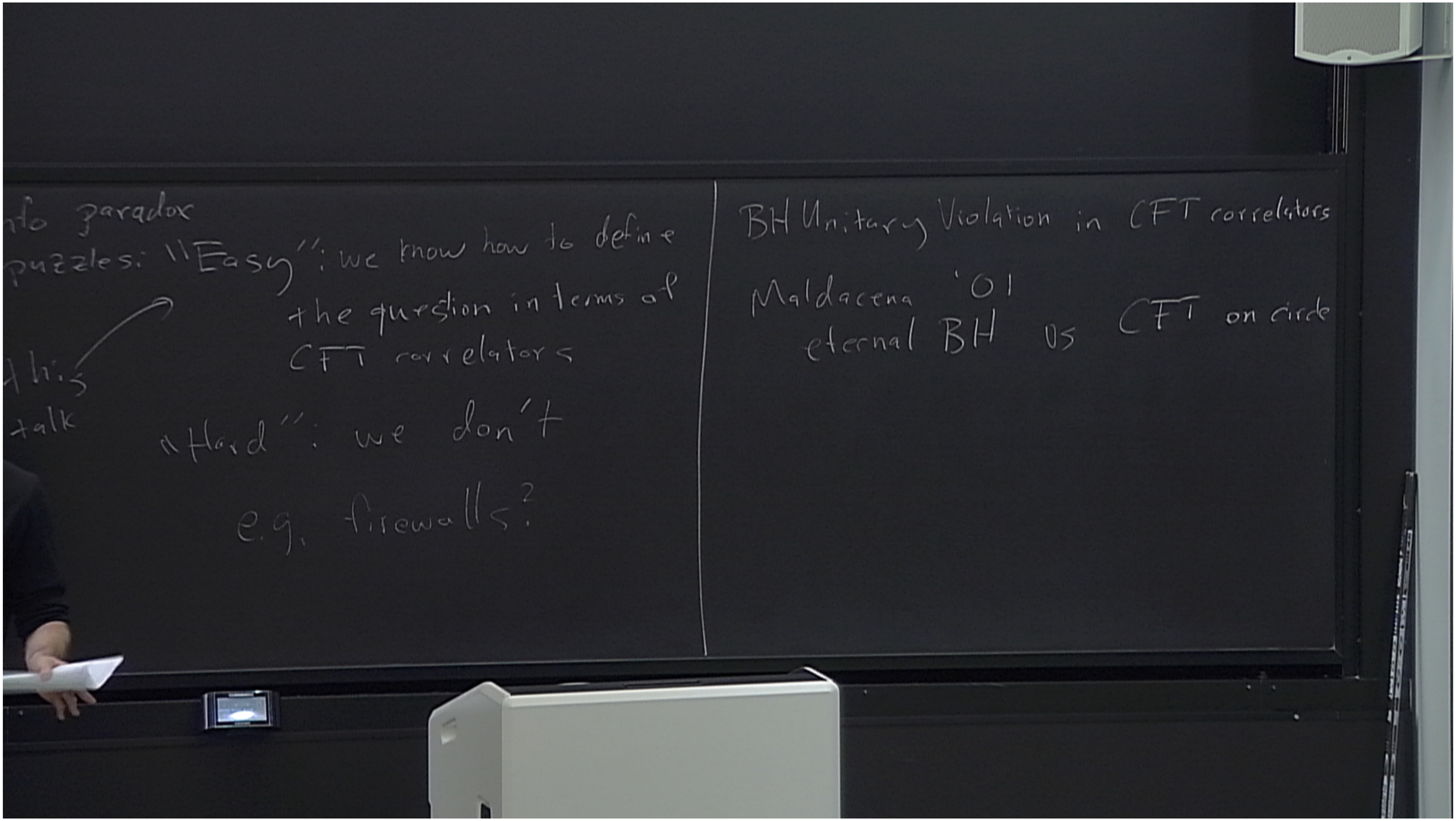
CFT correlators
this
talk
"Hard": we don't
e.g. firewalls?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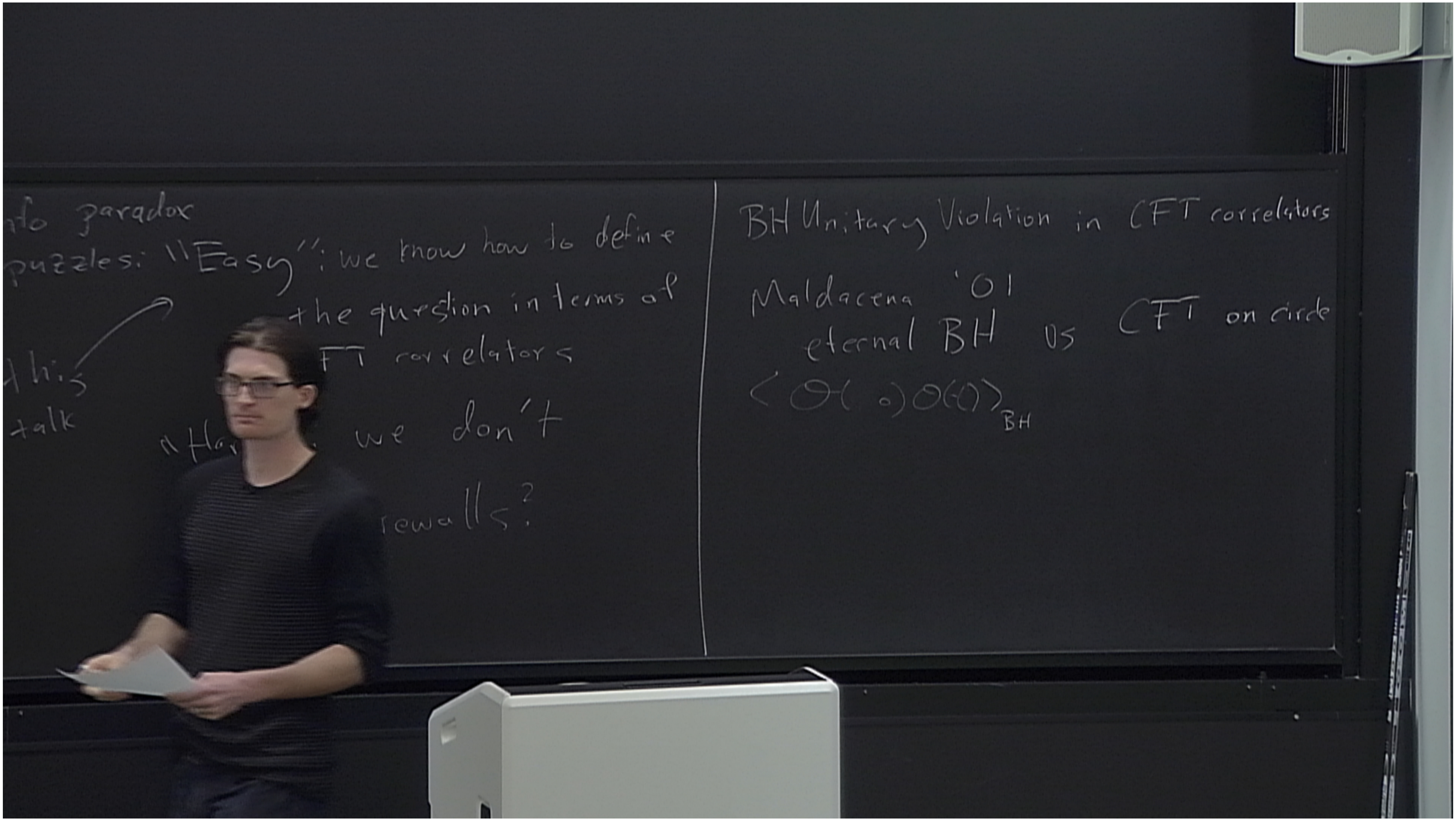
BH Unitary Violation in CFT correlators
Maldacena '01
eternal BH vs CFT on circle



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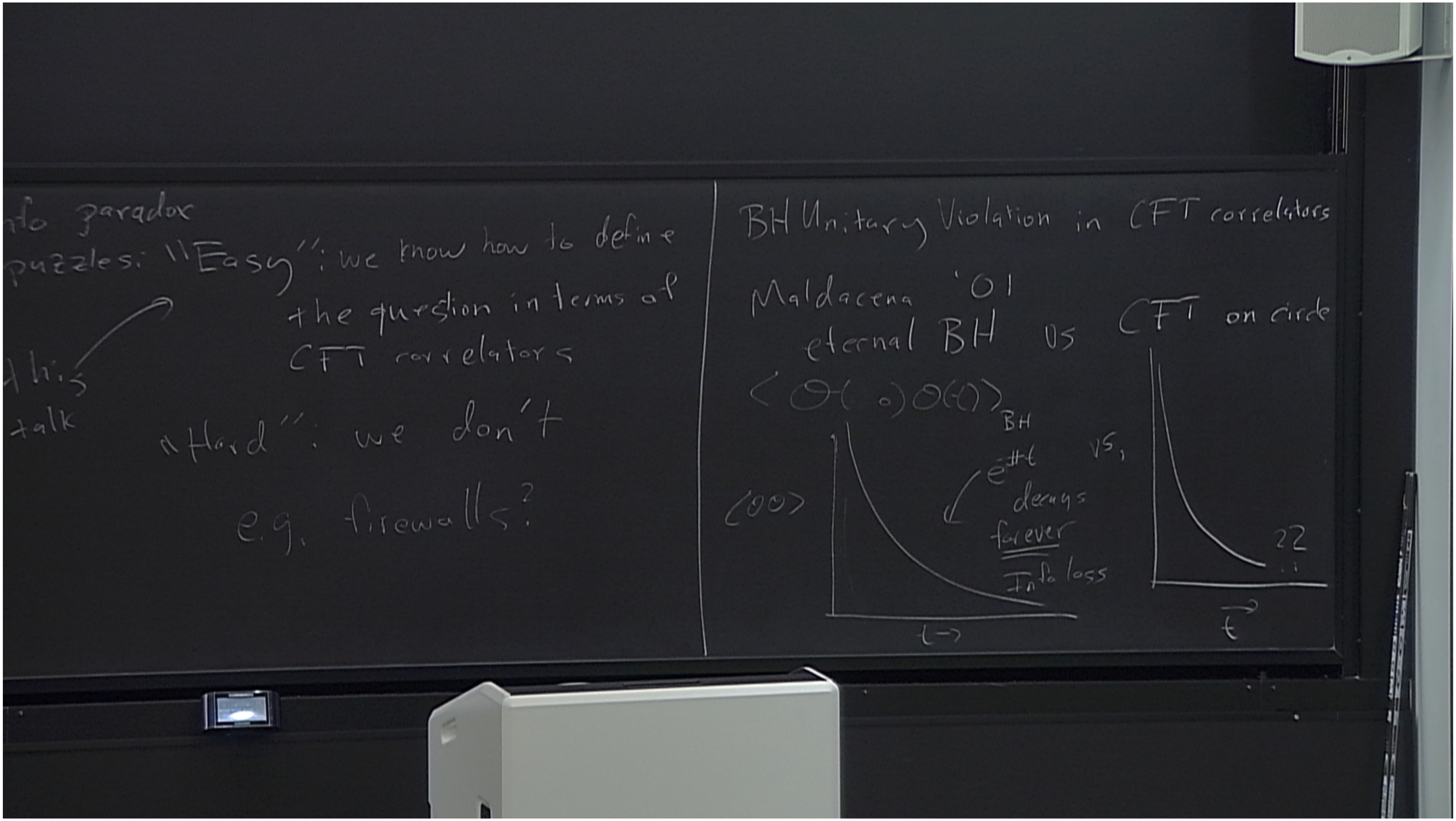
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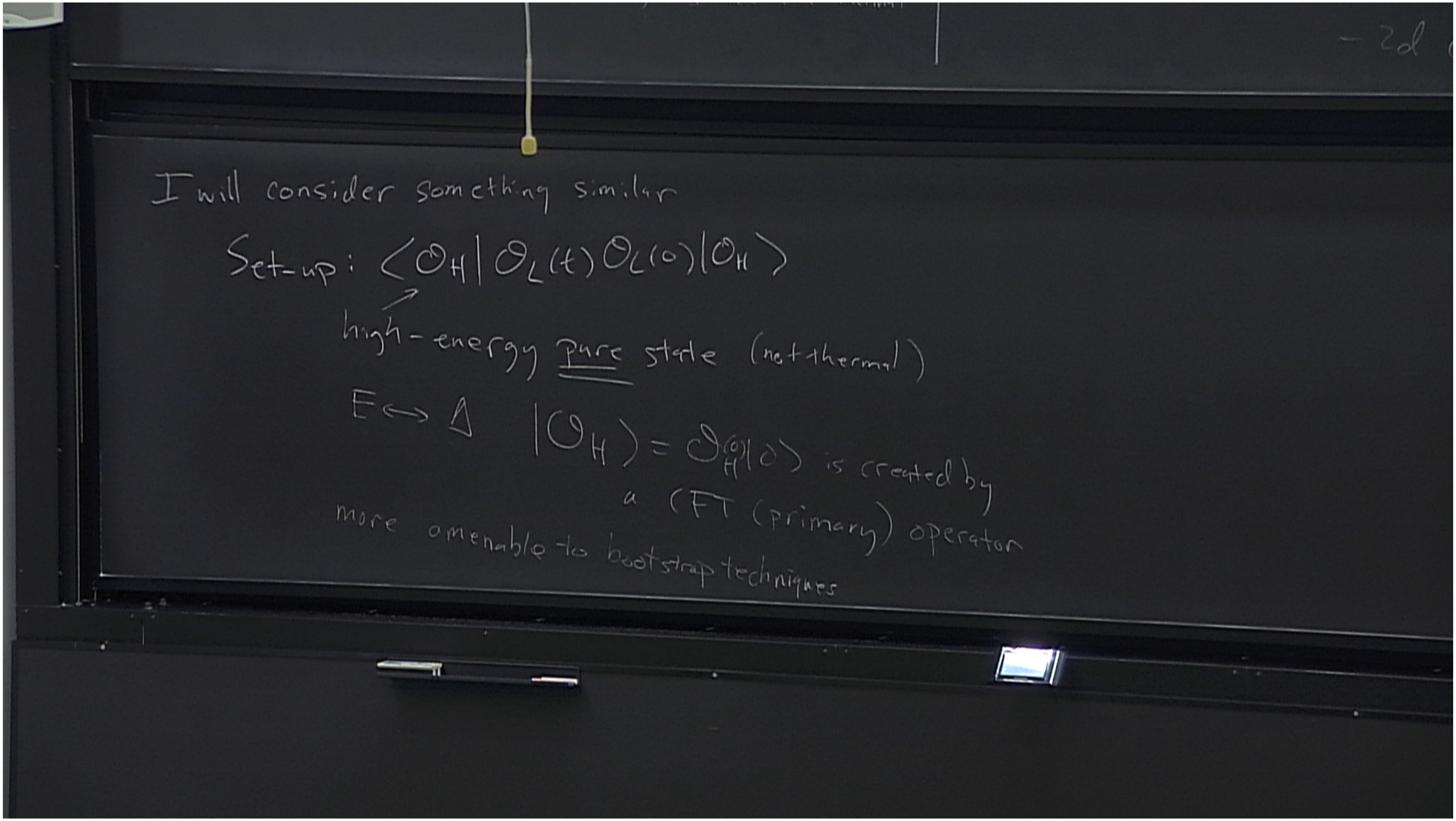
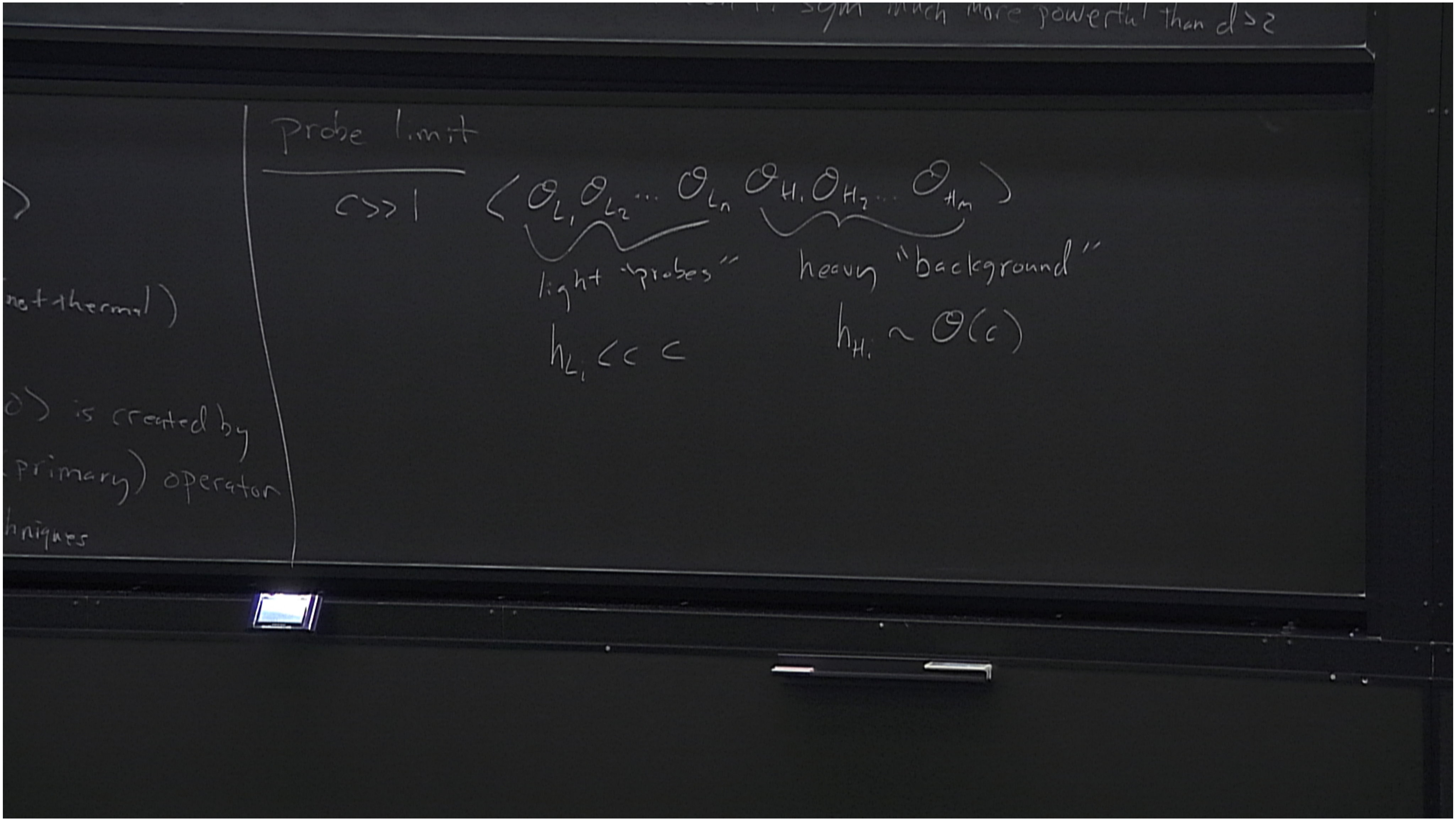
BH
vs,
decays
forever
Info loss
??
t→
t→


I will consider something similar
Set-up: $\langle O_H | O_L(t) O_L(0) | O_H \rangle$
high-energy pure state (not thermal)
$E \leftrightarrow \Delta$
$|O_H\rangle = O_H(0)|0\rangle$ is created by
a CFT (primary) operator
more amenable to bootstrap techniques


sym much more powerful than d>2
Probe limit
c>>1
$\langle \mathcal{O}_{L_1} \mathcal{O}_{L_2} \cdots \mathcal{O}_{L_n} \mathcal{O}_{H_1} \mathcal{O}_{H_2} \cdots \mathcal{O}_{H_m} \rangle$
light "probes"
heavy "background"
$h_{L_i} << c$
$h_{H_i} \sim \mathcal{O}(c)$
not thermal)
is created by
primary) operator
hniques

... sym much more powerful than d > 2

)

not thermal)

... ⟩ is created by
(primary) operator
...hniques

probe limit

$c \gg 1$ $\langle \mathcal{O}_{L_1} \mathcal{O}_{L_2} \cdots \mathcal{O}_{L_n} \mathcal{O}_{H_1} \mathcal{O}_{H_2} \cdots \mathcal{O}_{H_m} \rangle$

light "probes" heavy "background"

$1 \ll h_{L_i} \ll c$ $h_{H_i} \sim \mathcal{O}(c)$

$\mathcal{O}_{L_i}$ "probes" background created by $\mathcal{O}_{H_i}$

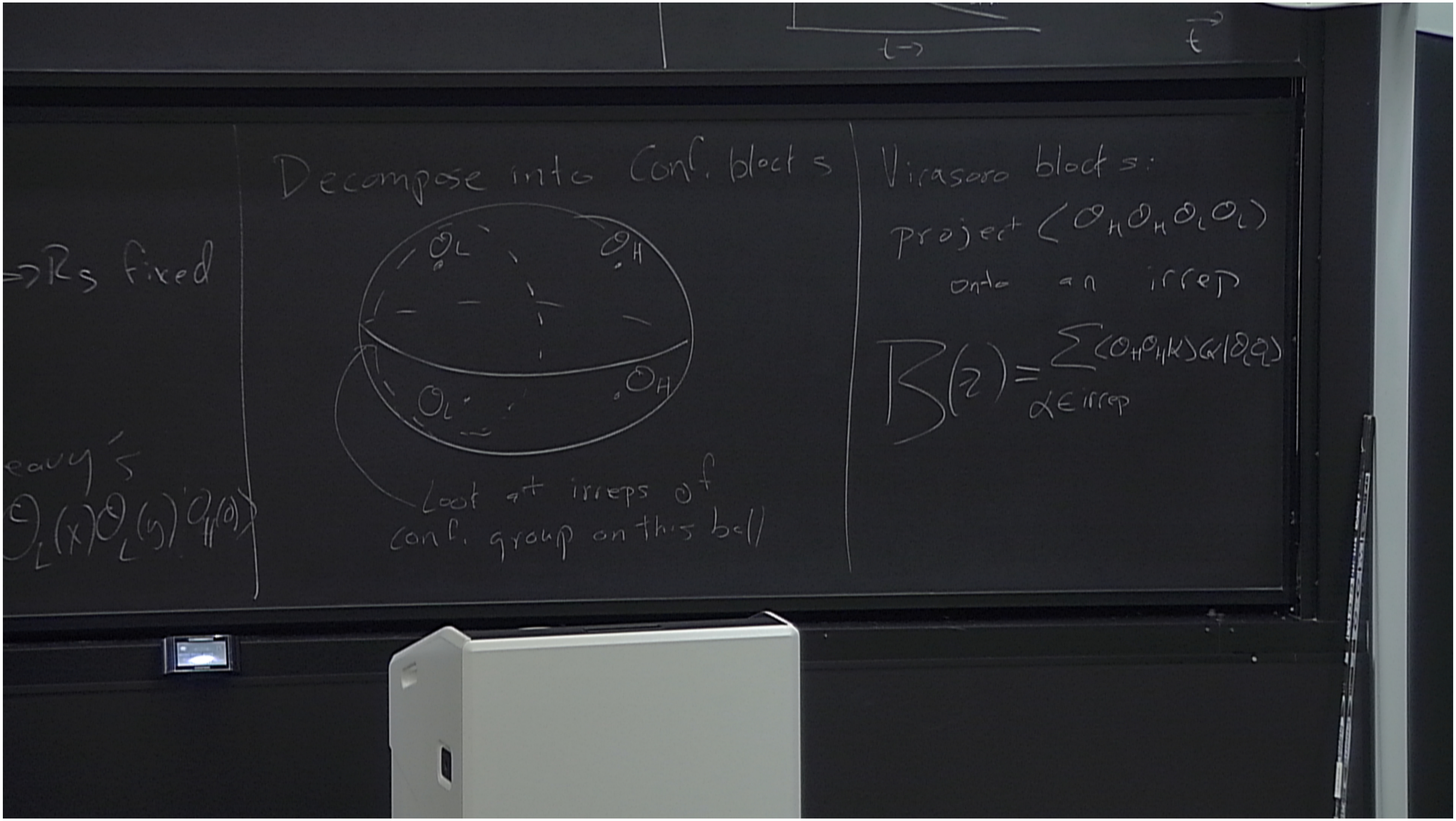
$|\mathcal{O}_{H_i}\rangle \cong$ microstates of AdS geometry

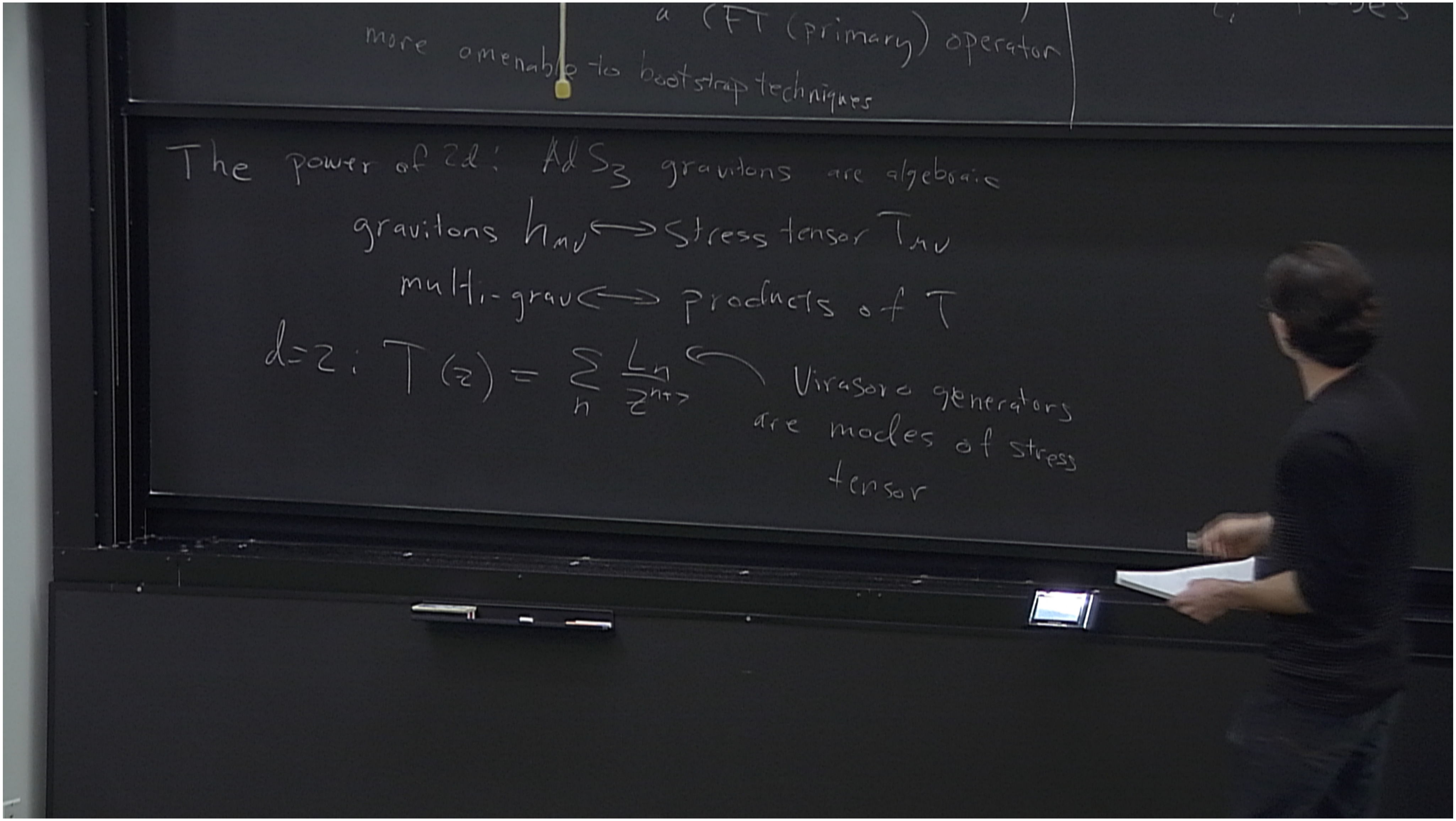
Recall: $h_H \longleftrightarrow M_H \implies \frac{h_H}{c} \longleftrightarrow G_N M_H \Rightarrow R_s$ fixed

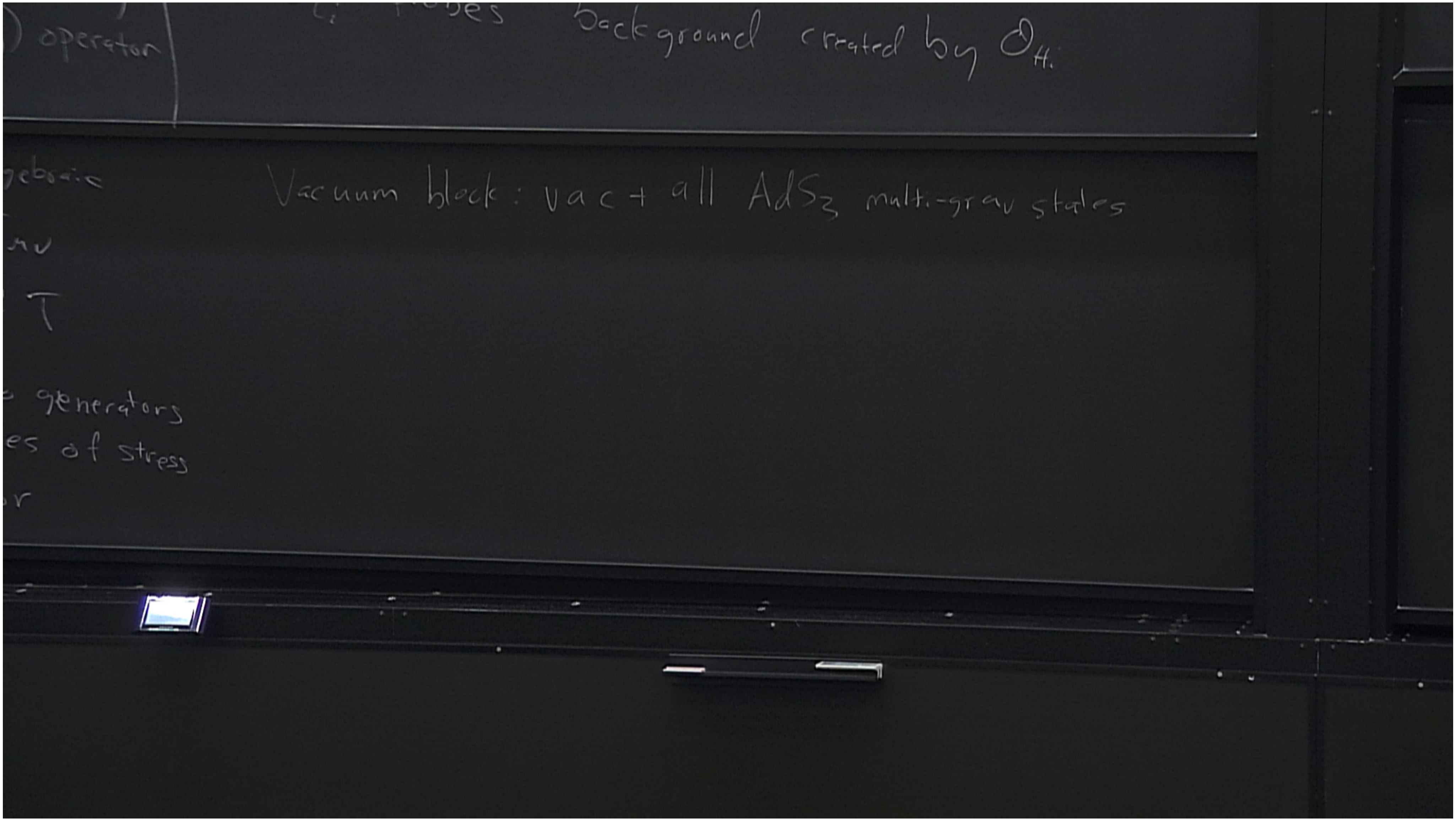
$c \longleftrightarrow \frac{1}{G_N}$

Simplest non-trivial case: 2 light's & 2 heavy's

$$\langle \mathcal{O}_H | \mathcal{O}_L(x) \mathcal{O}_L(y) | \mathcal{O}_H \rangle = \langle \mathcal{O}_H(\infty) \mathcal{O}_L(x) \mathcal{O}_L(y) \mathcal{O}_H(0) \rangle$$


Decompose into Conf. blocks
Virasoro blocks:
project ⟨O_H O_H O_L O_L⟩
onto an irrep
B(z) = Σ ⟨O_H O_H|α⟩⟨α|O_L O_L⟩
α∈irrep
Look at irreps of
conf. group on this ball
⇒ R_s fixed
O_L
O_H


a CFT (primary) operator
more amenable to bootstrap techniques
The power of 2d: AdS3 gravitons are algebraic
gravitons $h_{\mu\nu} \longleftrightarrow$ stress tensor $T_{\mu\nu}$
multi-grav $\longleftrightarrow$ products of T
$d=2$: $T(z) = \sum_n \frac{L_n}{z^{n+2}}$
Virasoro generators are modes of stress tensor


operator
background created by O_H
Vacuum block : vac + all AdS_3 multi-grav states
generators
es of stress

) operator

... probes background created by $\mathcal{O}_{H}$

...gebraic

... T

... generators

...es of stress

...r

Vacuum block: vac + all AdS_3 multi-grav states

knows about GR!

Results from $\frac{1}{c}$ expansion:

Vacuum block $\quad \mathcal{B}_{vac}(t) = \left(\frac{(\pi T_H)^2}{\sin^2(\pi T_H t)}\right)\left[1 + \frac{1}{c}\left(h_L f_1(t T_H) + h_L^2 f_2(t T_H)\right) + \frac{1}{c^2}(\dots)\right)$

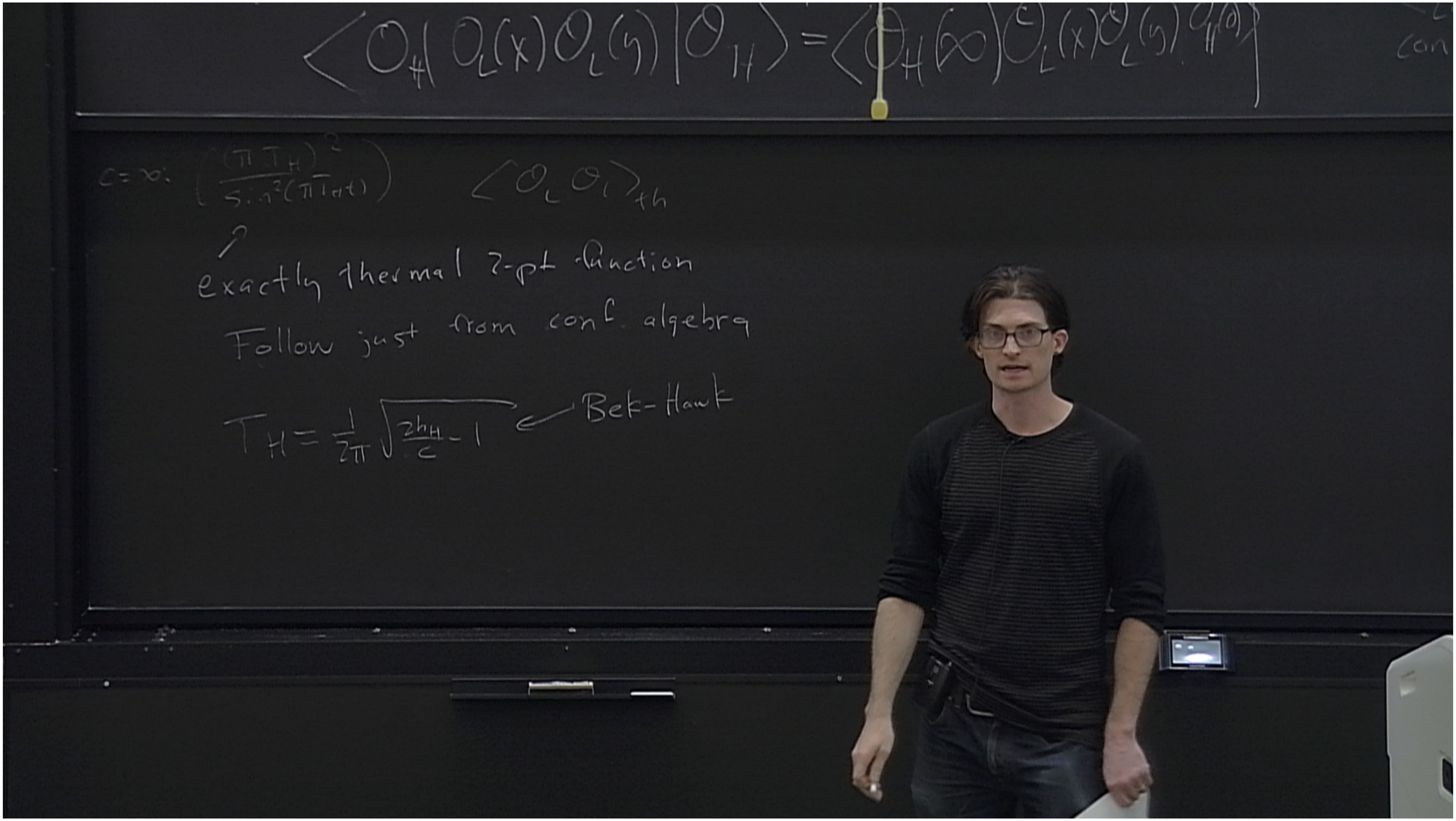
$z = e^{-t}$

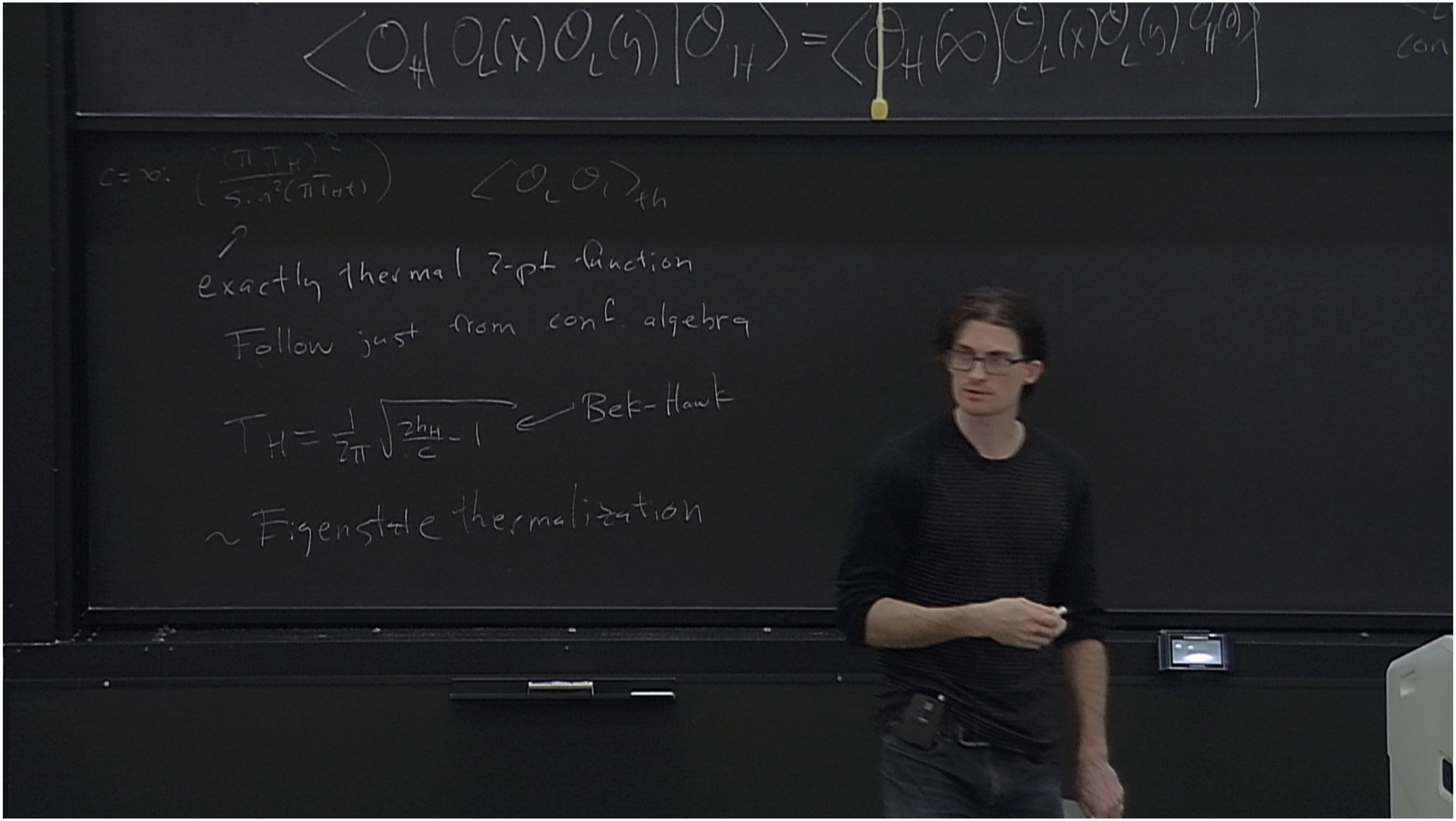
$$\langle O_H | O_L(x) O_L(y) | O_H \rangle = \langle O_H(\infty) O_L(x) O_L(y) O_H(0) \rangle$$

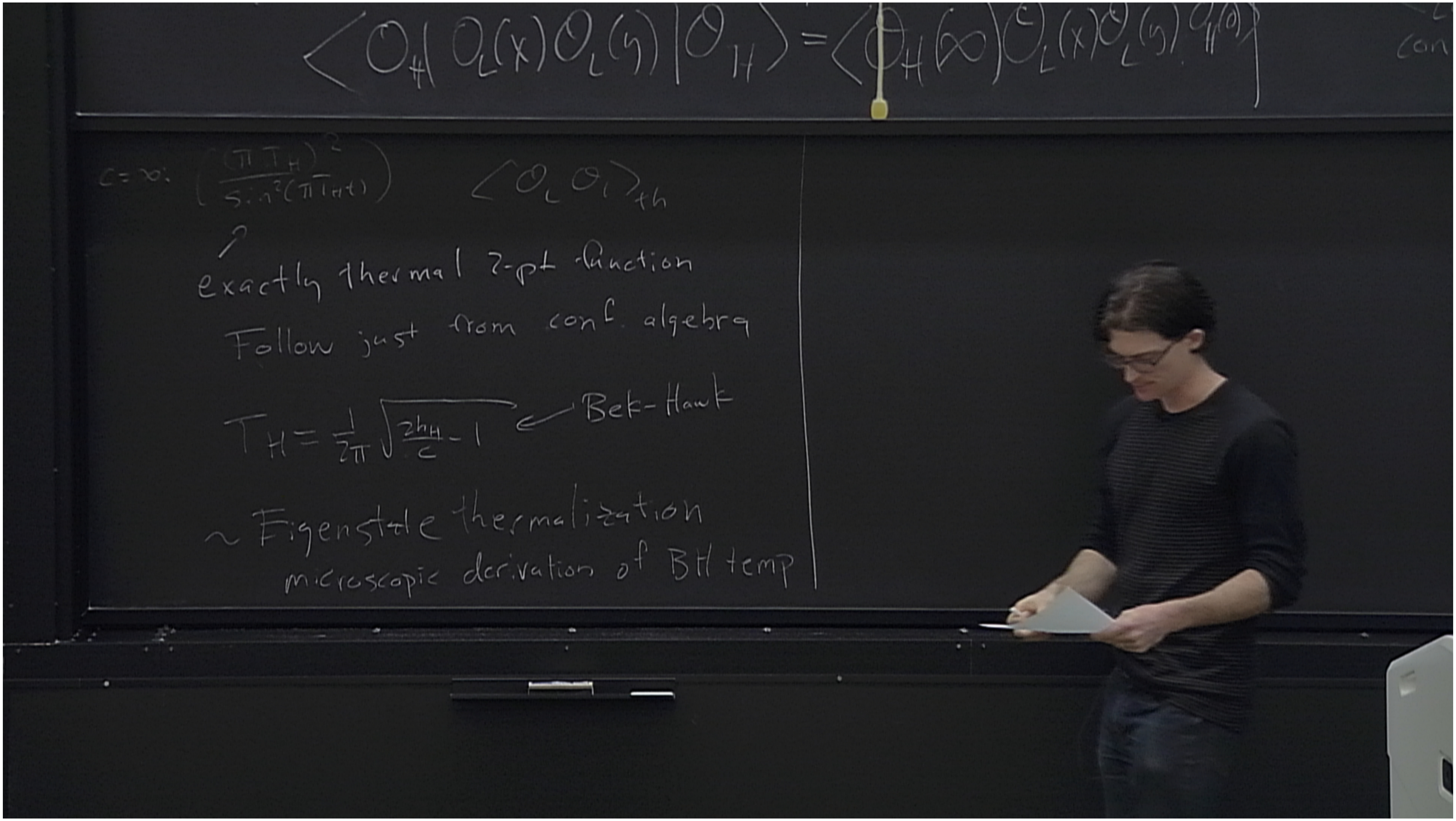
con

$c = \infty$: $\left(\frac{(\pi T_H)^2}{\sin^2(\pi T_H t)} \right)$ $\langle O_L O_L \rangle_{th}$

↗ exactly thermal 2-pt function


⟨O_H| O_L(x) O_L(y) |O_H⟩ = ⟨O_H(∞) O_L(x) O_L(y) O_H(0)⟩
c = ∞: (πT_H)^2 / sin^2(πT_H t)
⟨O_L O_L⟩_th
exactly thermal 2-pt function
Follow just from conf. algebra
T_H = 1/2π √(2h_H/c − 1)
Bek-Hawk


$\langle O_H | O_L(x) O_L(y) | O_H \rangle = \langle O_H(\infty) O_L(x) O_L(y) O_H(0) \rangle$
$c = \infty$: $\left(\frac{(\pi T_H)^2}{\sin^2(\pi T_H t)} \right)$
$\langle O_L O_L \rangle_{th}$
exactly thermal 2-pt function
Follow just from conf. algebra
$T_H = \frac{1}{2\pi} \sqrt{\frac{2h_H}{c} - 1}$
Bek-Hawk
~ Eigenstate thermalization


$\langle O_H | O_L(x) O_L(y) | O_H \rangle = \langle O_H(\infty) O_L(x) O_L(y) O_H(0) \rangle$
$c=\infty$: $\left(\frac{\pi T_H}{\sin^2(\pi T_H t)} \right)^2$
$\langle O_L O_L \rangle_{th}$
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Follow just from conf. algebra
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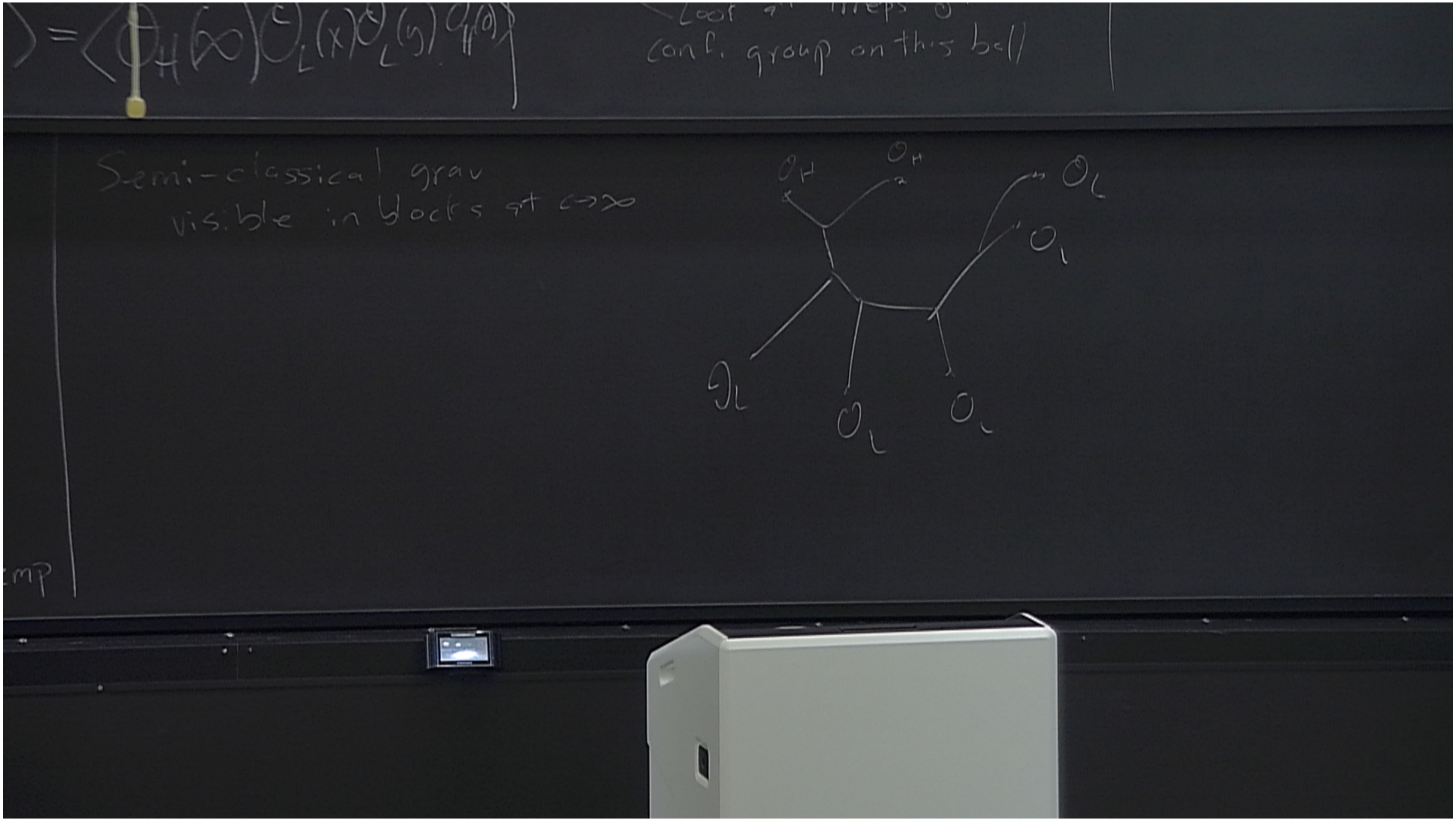
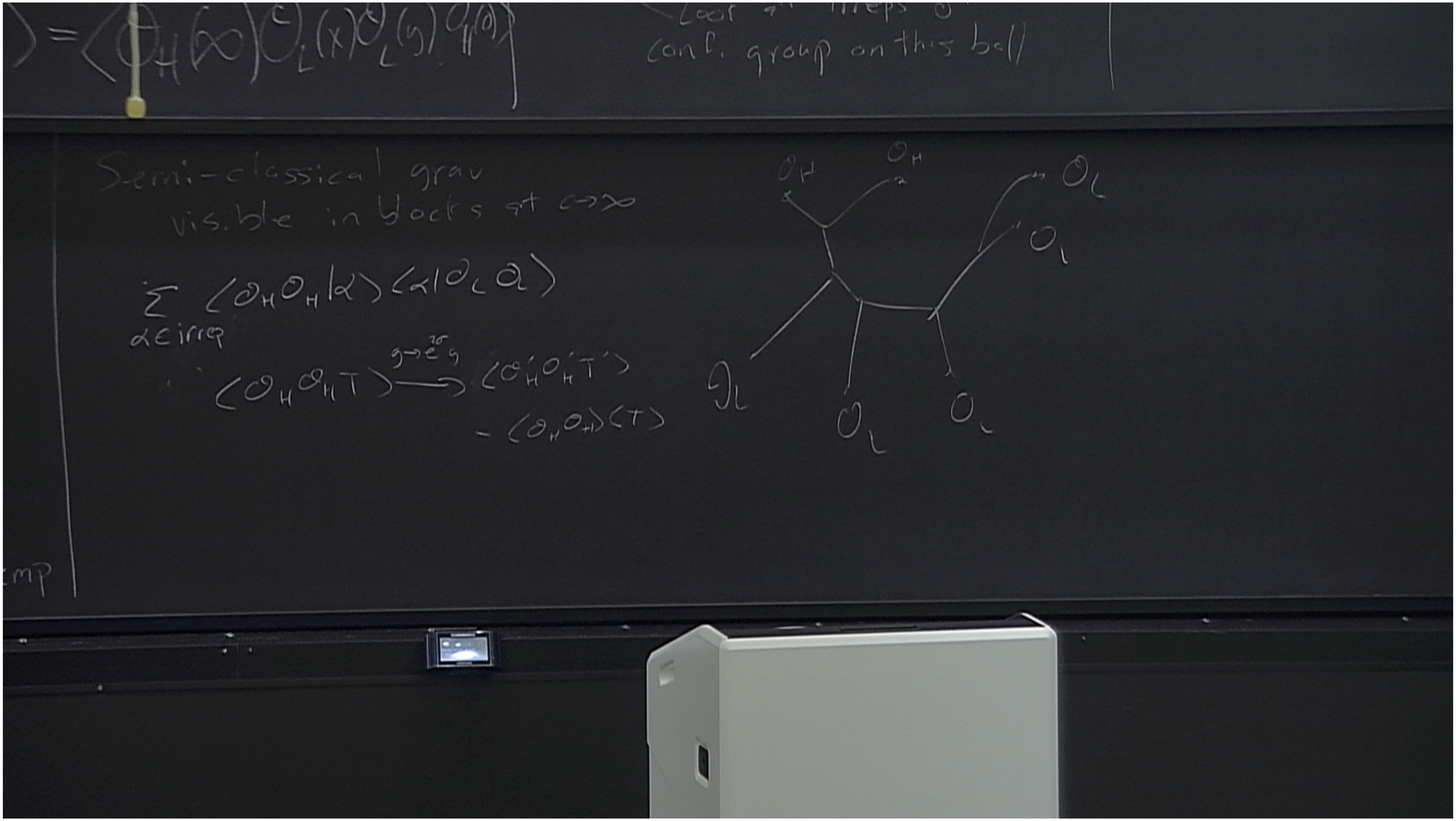
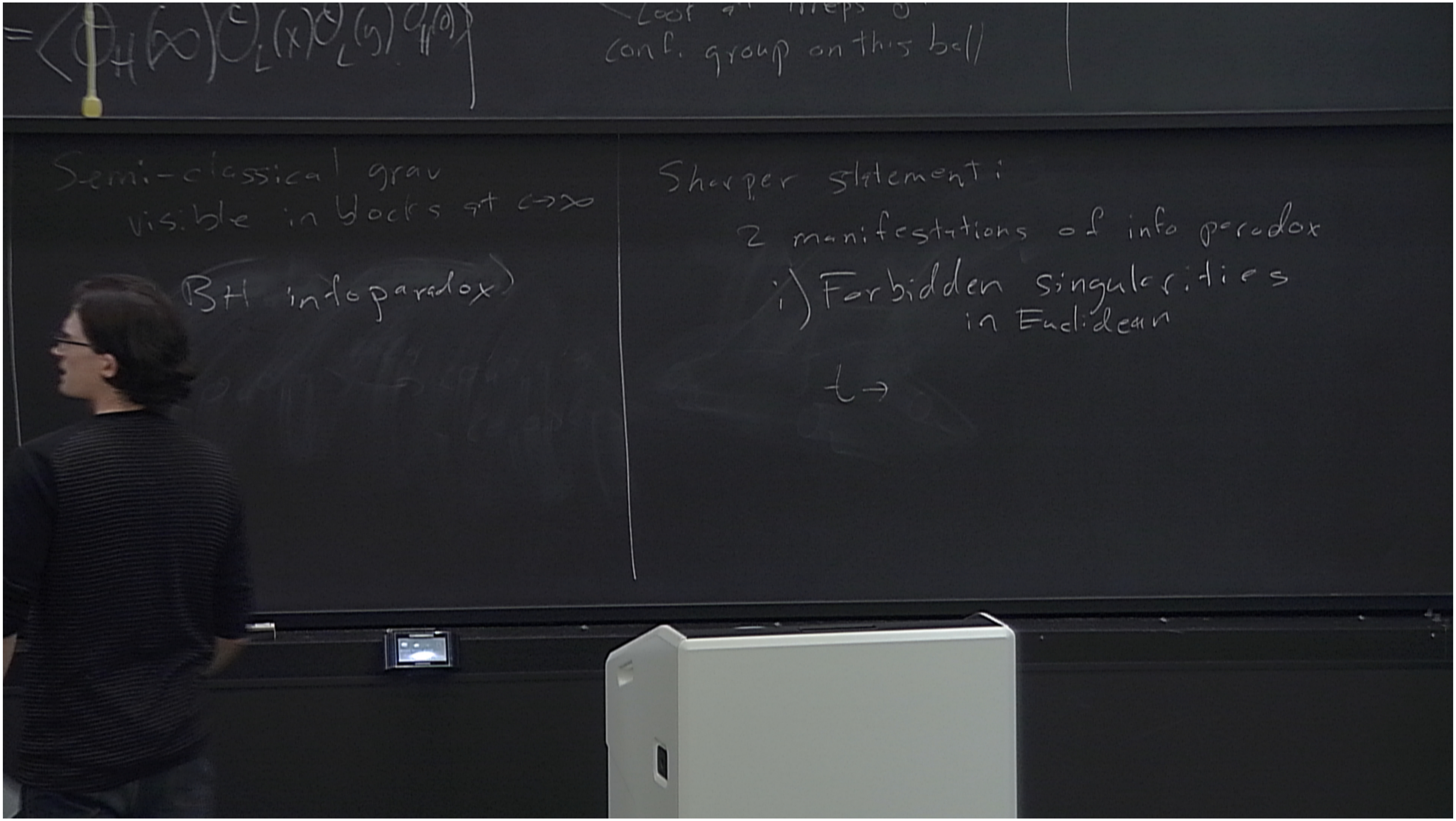
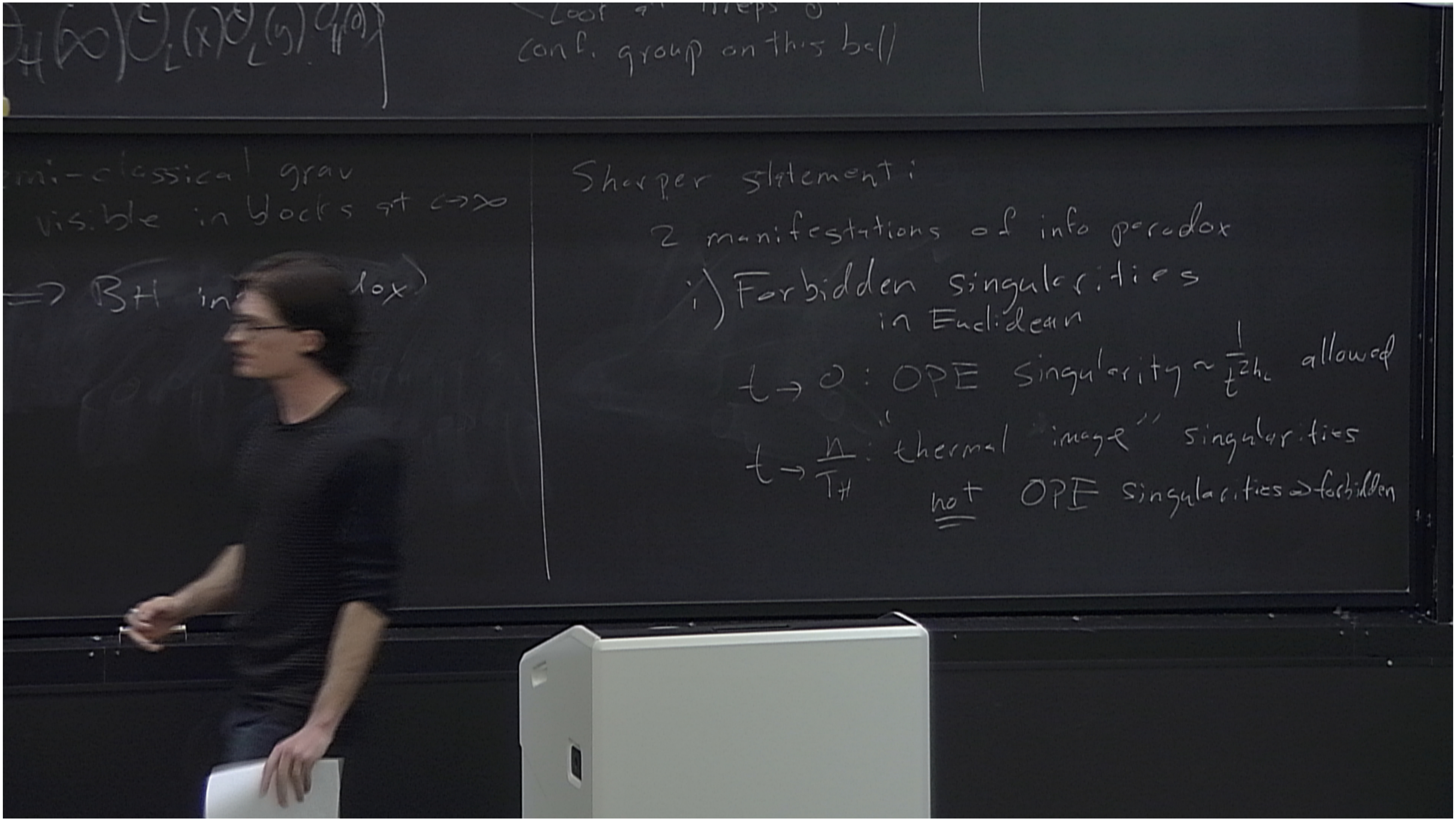
Bek-Hawk
~ Eigenstate thermalization
microscopic derivation of BH temp


conf. group on this ball
Semi-classical grav
visible in blocks at c→∞


conf. group on this ball
Semi-classical grav
visible in blocks at c→∞
Σ ⟨O_H O_H|α⟩⟨α|O_L O_L⟩
α∈irrep
⟨O_H O_H T⟩ → ⟨O'_H O'_H T'⟩
− ⟨O_H O_H⟩⟨T⟩
O_H
O_L


conf. group on this ball
Semi-classical grav
visible in blocks at c→∞
BH infoparadox
Sharper statement:
2 manifestations of info paradox
i) Forbidden singularities
in Euclidean
t→


conf. group on this ball
visible in blocks at c→∞
Sharper statement:
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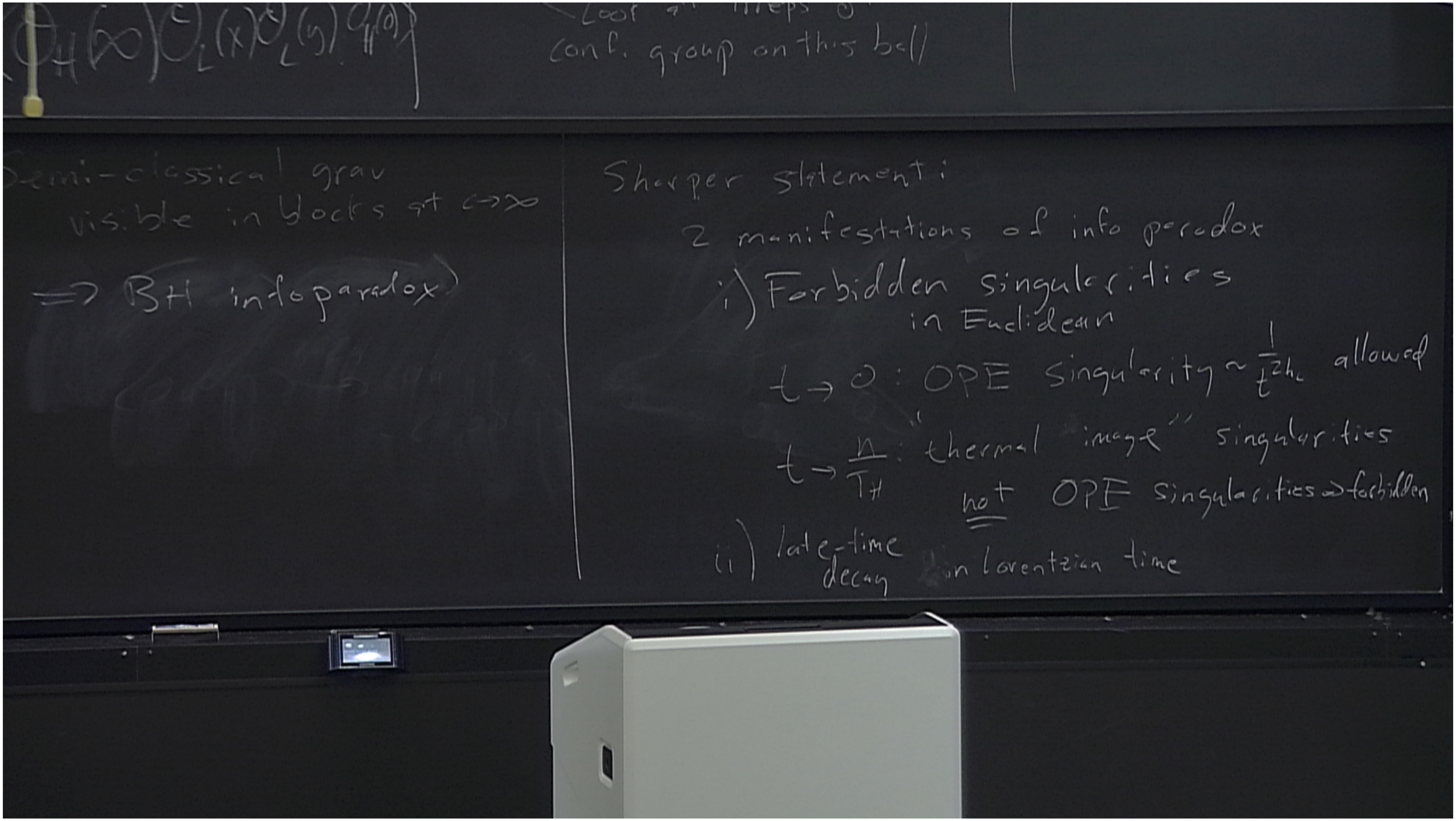
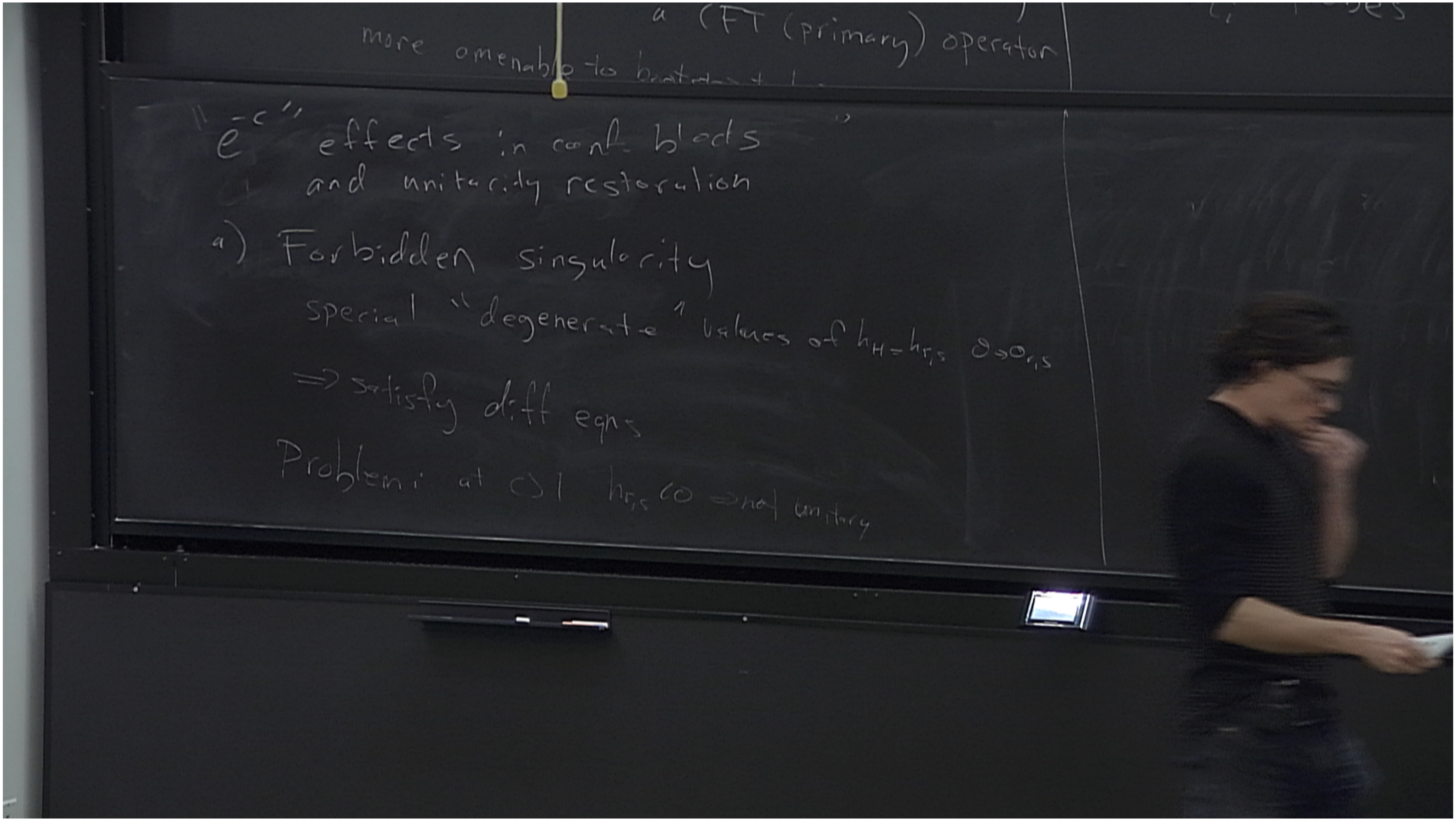
i) Forbidden singularities
in Euclidean
t→0: OPE singularity ~ 1/t^{2h_L} allowed
t→ n/T_H: "thermal image" singularities
not OPE singularities ⇒ forbidden


conf. group on this ball
Semi-classical grav
visible in blocks at c→∞
⇒ BH infoparadox
Sharper statement:
2 manifestations of info paradox
i) Forbidden singularities
in Euclidean
t→0 : OPE singularity ~ 1/t^{2h_L} allowed
t→ n/T_H : "thermal image" singularities
not OPE singularities ⇒ forbidden
ii) late-time decay in Lorentzian time


(FT (primary) operator
more amenable to
"e^{-c}" effects in conf. blocks
and unitarity restoration
a) Forbidden singularity
special "degenerate" values of h_H = h_{r,s} O→O_{r,s}
⇒ satisfy diff eqns
Problem: at c>1 h_{r,s} < 0 ⇒ not unitary

$\mathcal{O}_{L_i}$ "probes" background created by $\mathcal{O}_{H_i}$

created by

) operator

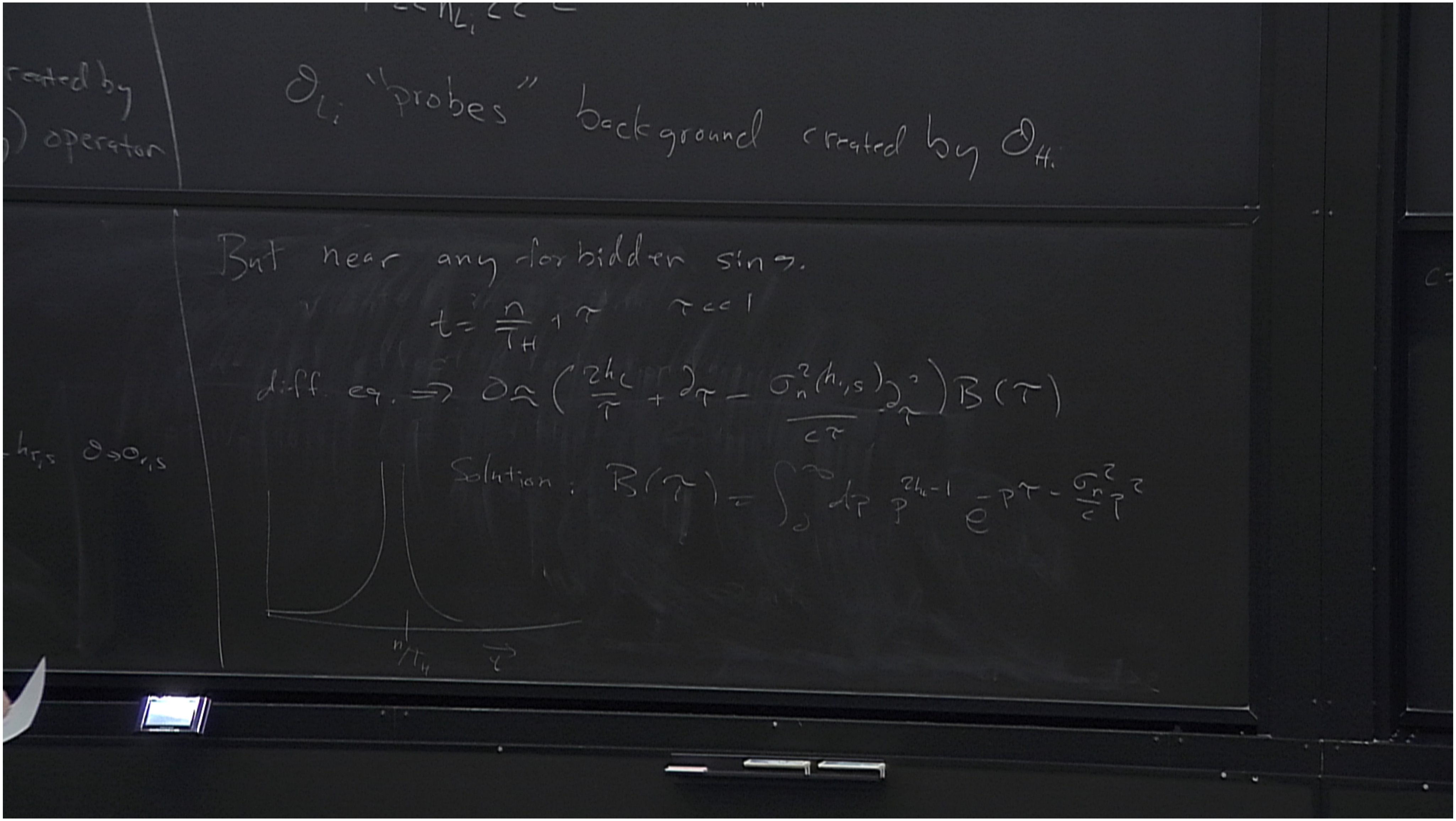
But near any forbidden sing.

$t = \frac{n}{T_H} + \tau \qquad \tau \ll 1$

diff. eq. $\Rightarrow$ $\mathcal{O} \simeq \left(\frac{2h_L}{\tau} + \partial_\tau - \frac{\sigma_n^2(h_{r,s})}{c\tau} \partial_\tau^2 \right) B(\tau)$

$h_{r,s} \quad \mathcal{O} \to \mathcal{O}_{r,s}$

Solution: $B(\tau) = \int_0^\infty dp \, p^{2h_L - 1} e^{-p\tau - \frac{\sigma_n^2}{c} p^2}$



$\mathcal{O}_{L_i}$ "probes" background created by $\mathcal{O}_{H_i}$
But near any forbidden sing.
$t = \frac{n}{T_H} + \tau \quad \tau \ll 1$
diff. eq. $\Rightarrow \mathcal{D}_{\tau}\left(\frac{2h_L}{\tau} + \partial_\tau - \frac{\sigma_n^2(h_{r,s})}{c\tau}\partial_\tau^2\right)B(\tau)$
Solution: $B(\tau) = \int_0^\infty dp\, p^{2h_L-1}\, e^{-p\tau - \frac{\sigma_n^2}{c}p^2}$
n/T_H
τ

$\mathcal{O}_{L_i}$ "probes" background created by $\mathcal{O}_{H_i}$

But near any forbidden sing.

$t = \frac{n}{T_H} + \tau \qquad \tau \ll 1$

$h_{r,s} \gg c$

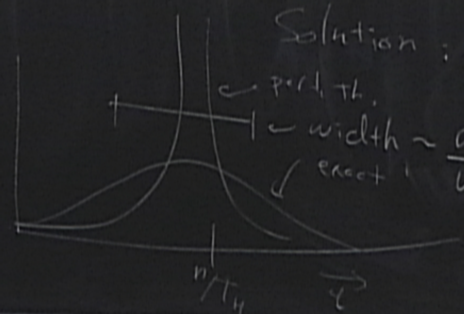
$\sigma_n^2(h_H) \simeq \frac{c}{6h_H} \int_0^{2\pi n} \frac{dt}{\tau} \sin^2(t/2)$

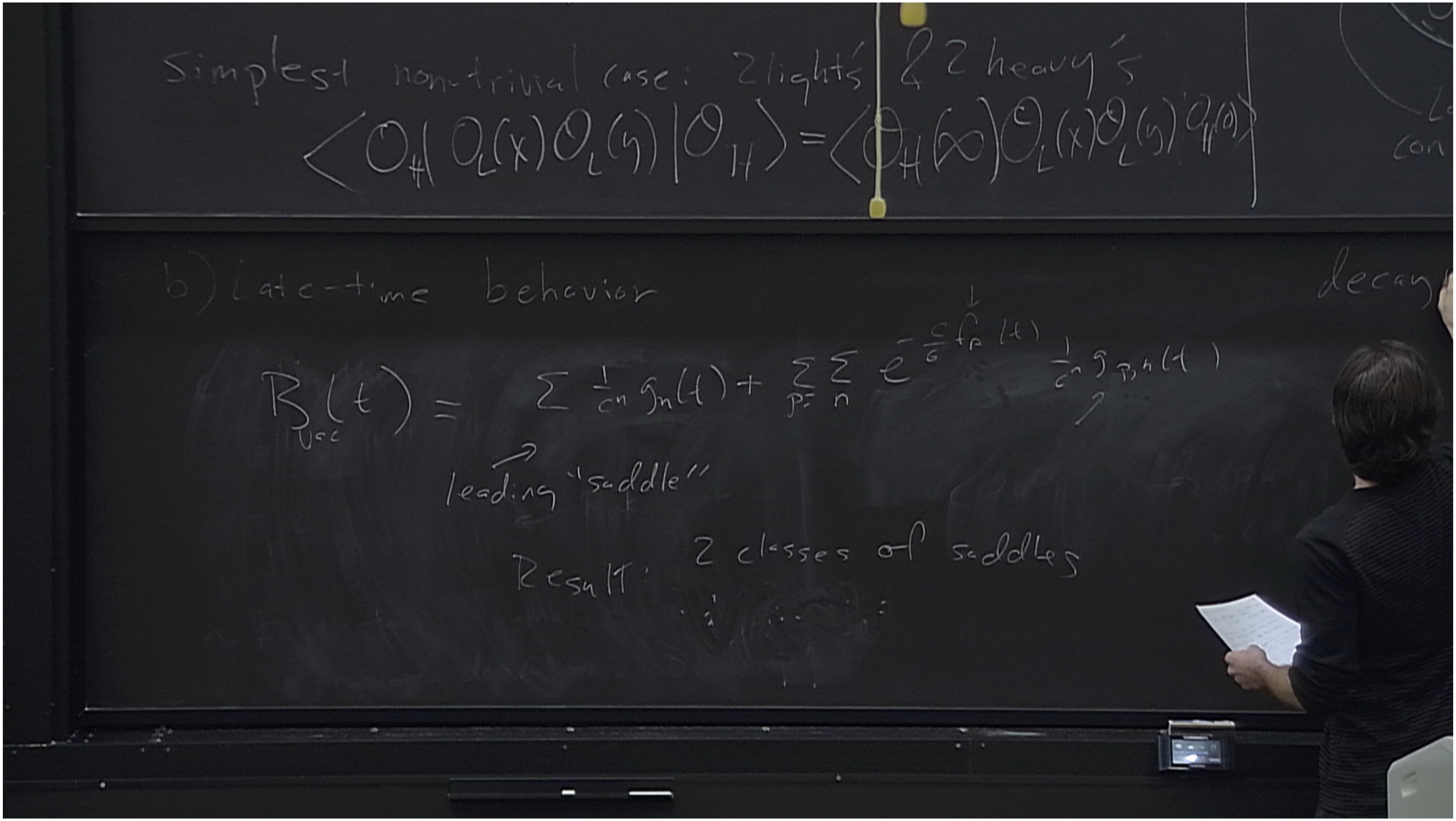
diff. eq. $\Rightarrow$ $0 \simeq \left(\frac{2h_L}{\tau} + \partial_\tau - \frac{\sigma_n^2(h_{r,s})}{c\tau} \partial_\tau^2 \right) B(\tau)$

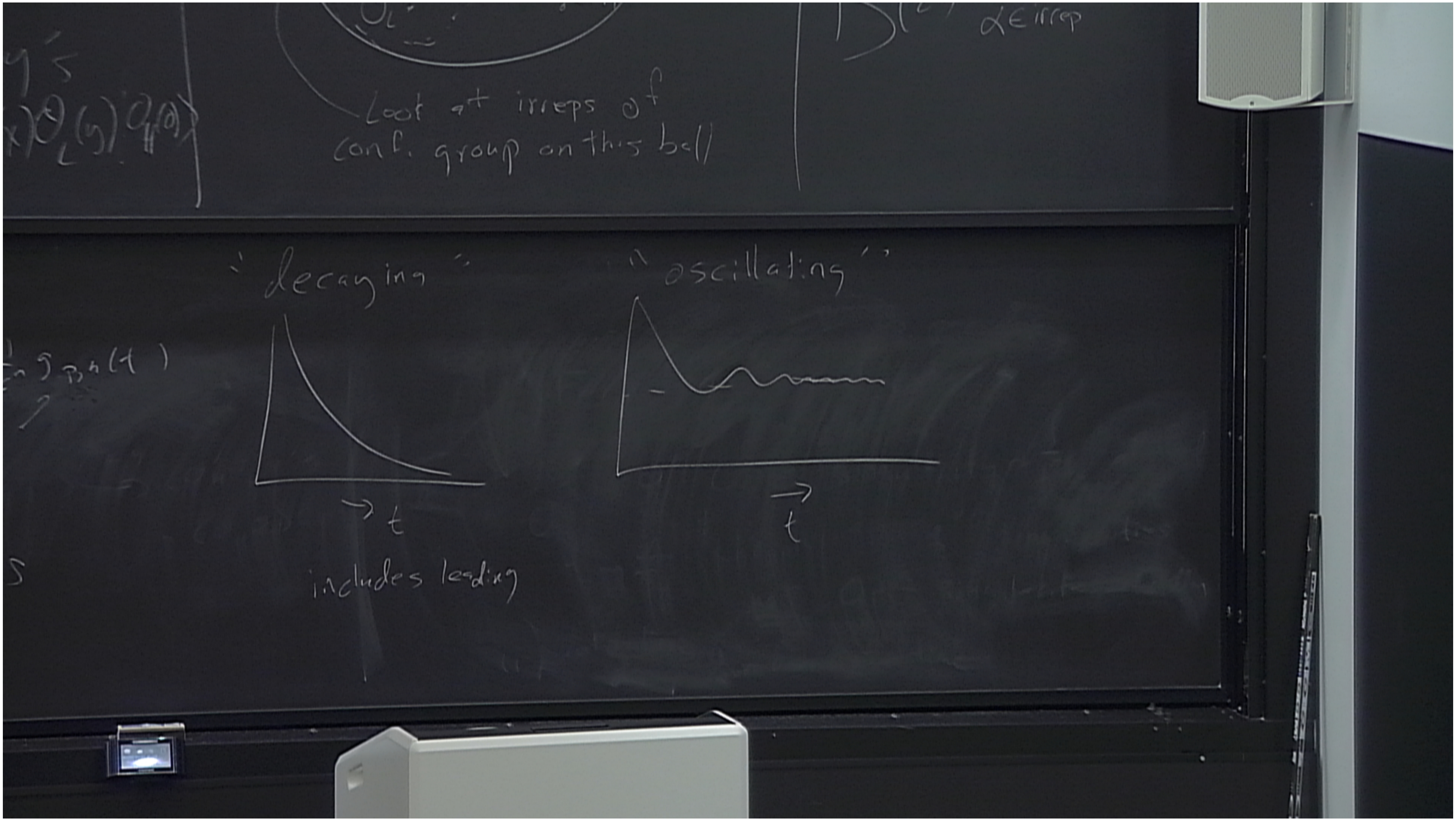
Solution: $B(\tau) = \int_0^\infty dp \, p^{2h_L - 1} e^{-p\tau - \frac{\sigma_n^2}{c} p^2}$

$\sim \frac{1}{\tau^{2h_L}} \left(1 + \frac{h_L}{c} f_1(\tau) + \ldots \right)$ ← pert. th.

$e^{-c\frac{\tau^2}{\sigma_n^2}} \left(g_0(\tau) + \frac{g_1(\tau)}{c} + \ldots \right)$ ← non-pert.




Simplest non-trivial case: 2 light's & 2 heavy's
b) Late-time behavior
decay
leading "saddle"
Result: 2 classes of saddles



Look at irreps of conf. group on this ball
"decaying"
"oscillating"
t
t
includes leading