Title: Ads/CFT

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Collection: AdS/CFT 2021/2022

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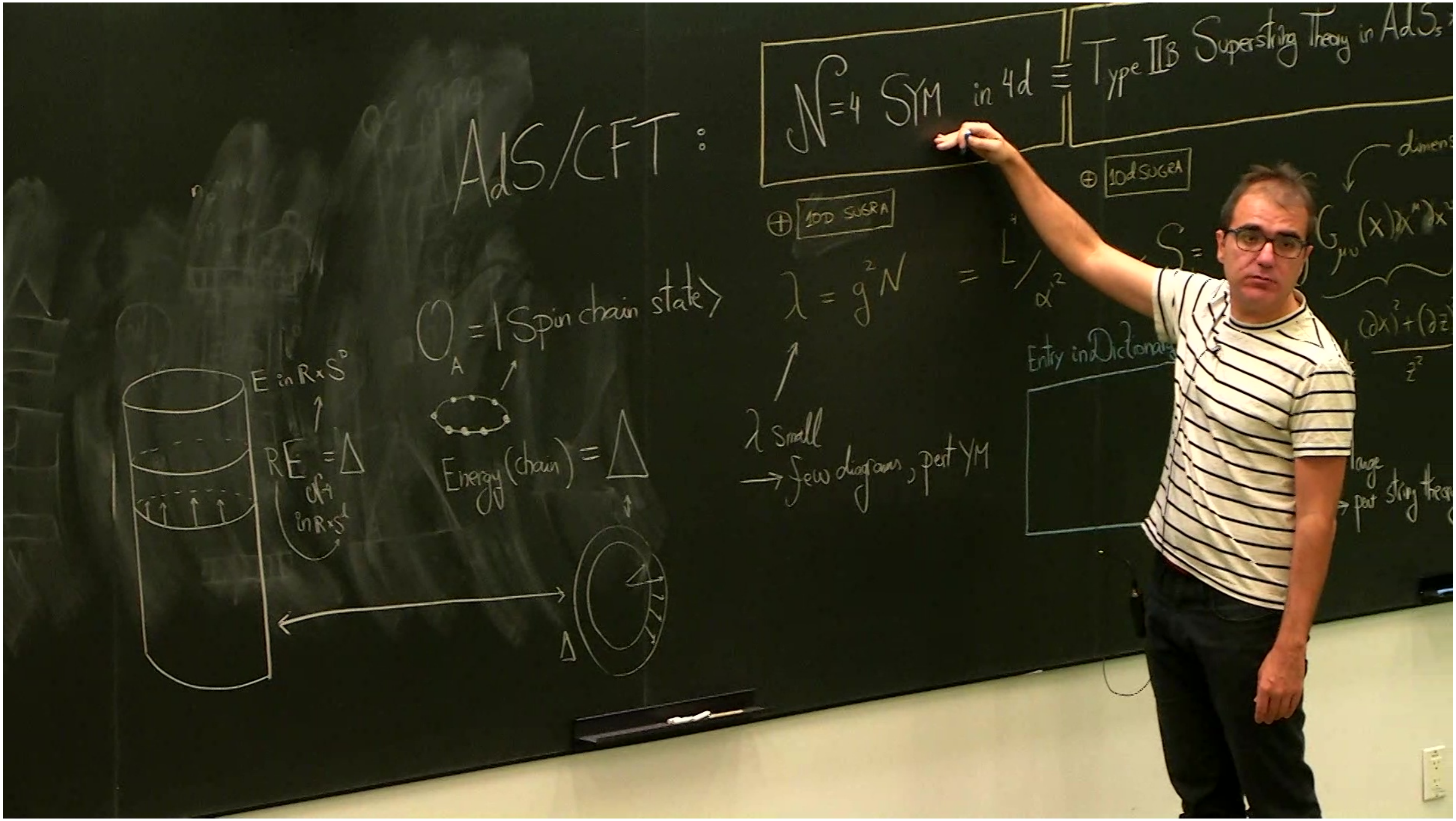
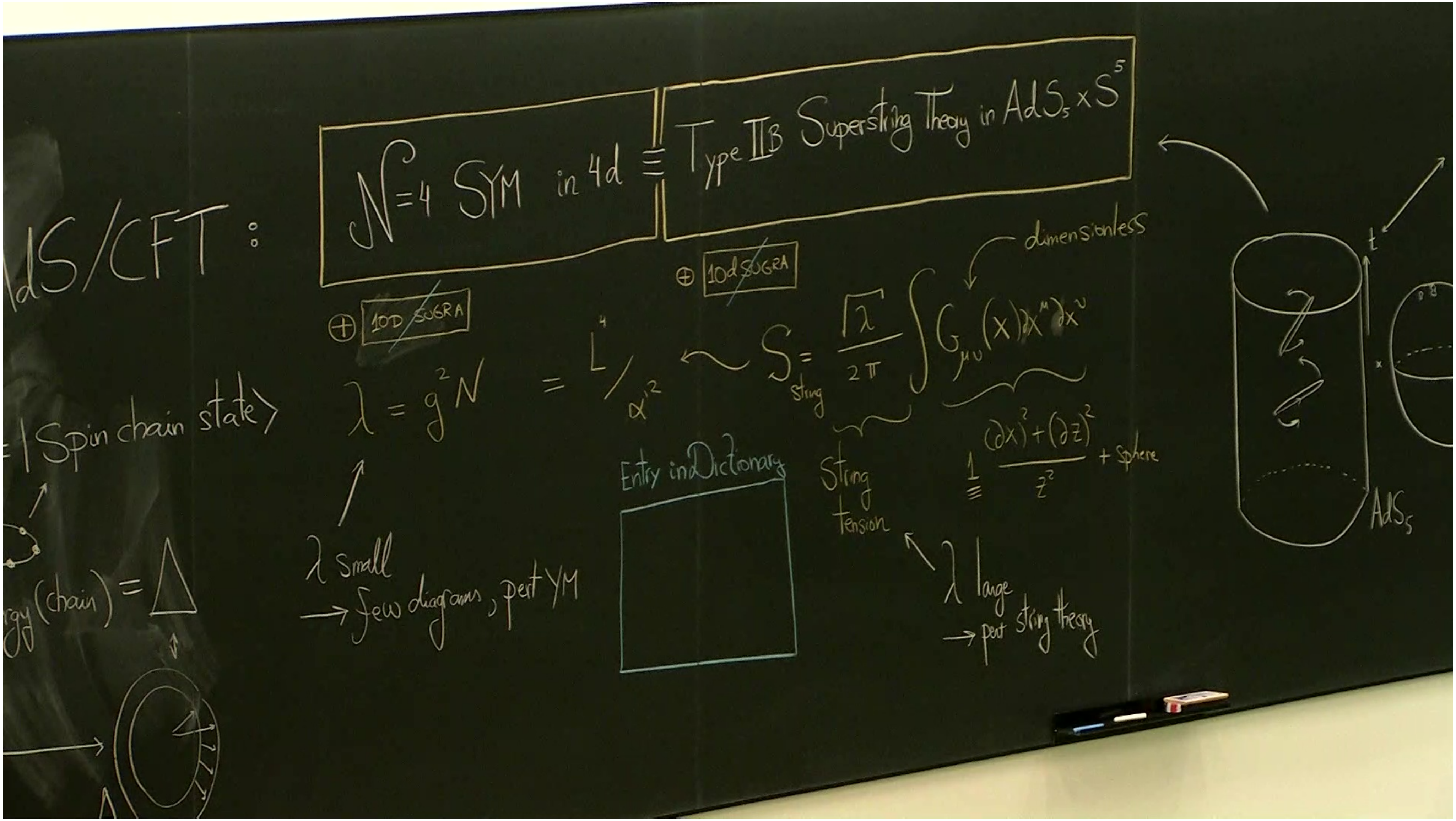
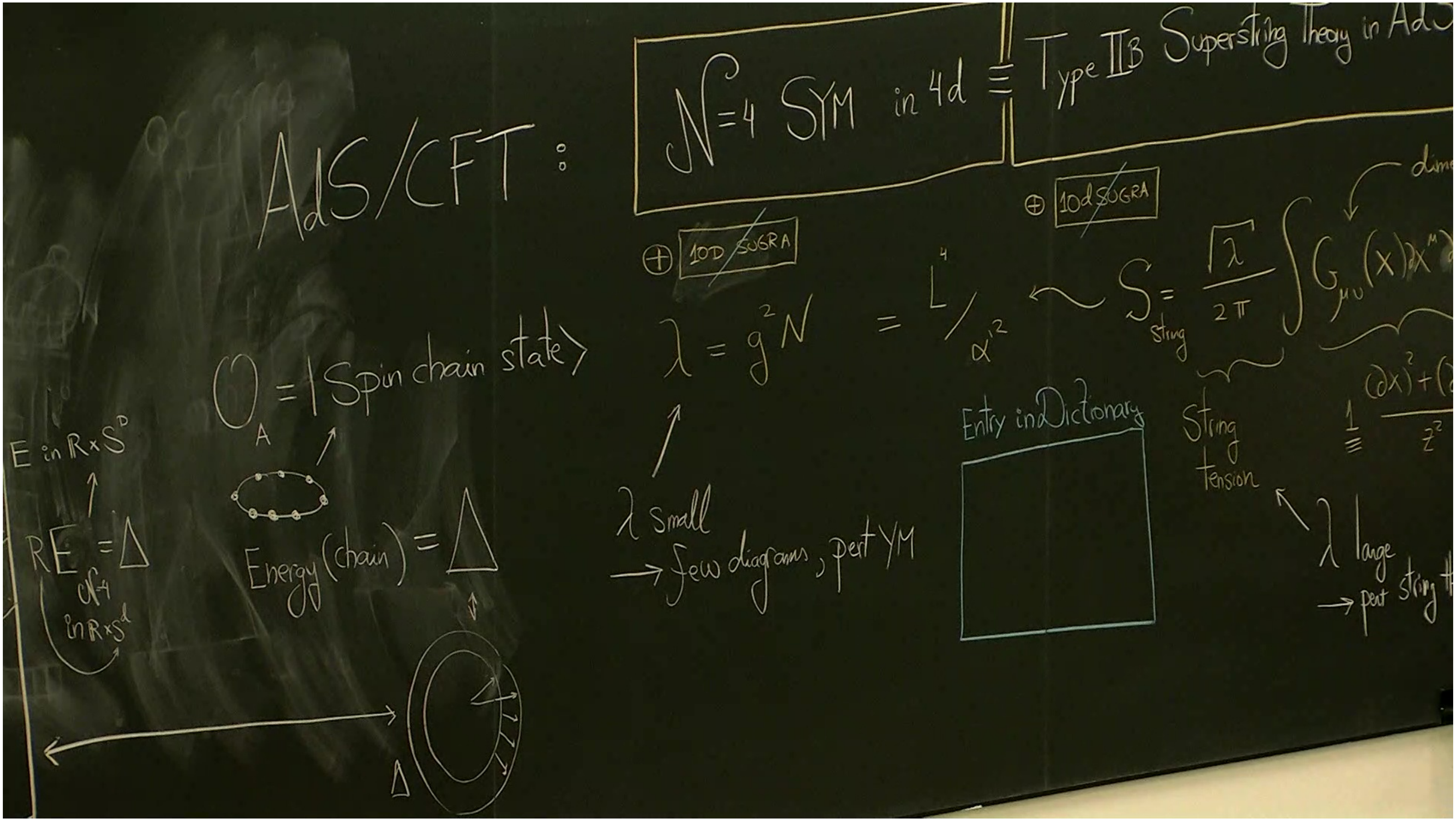
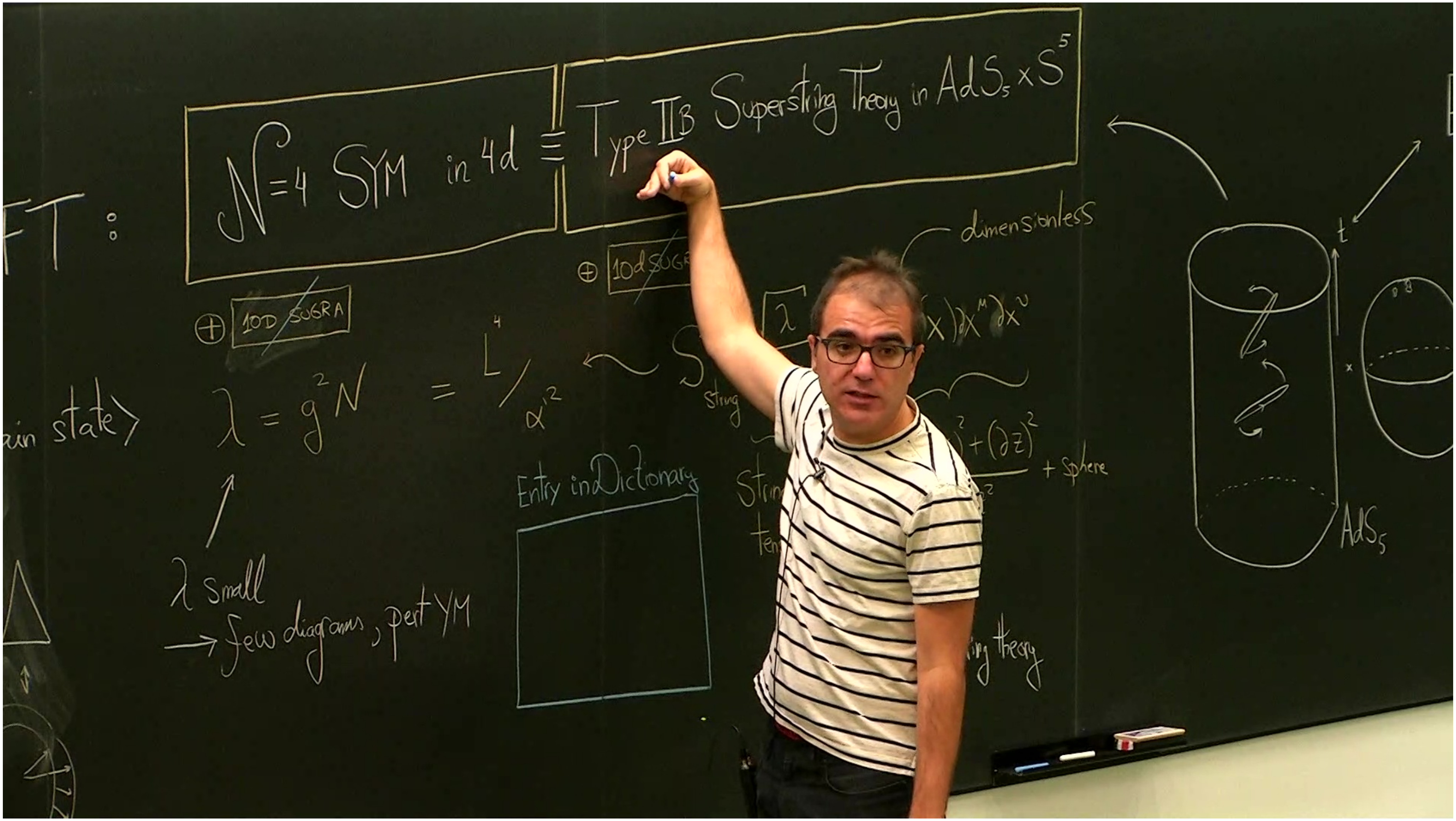


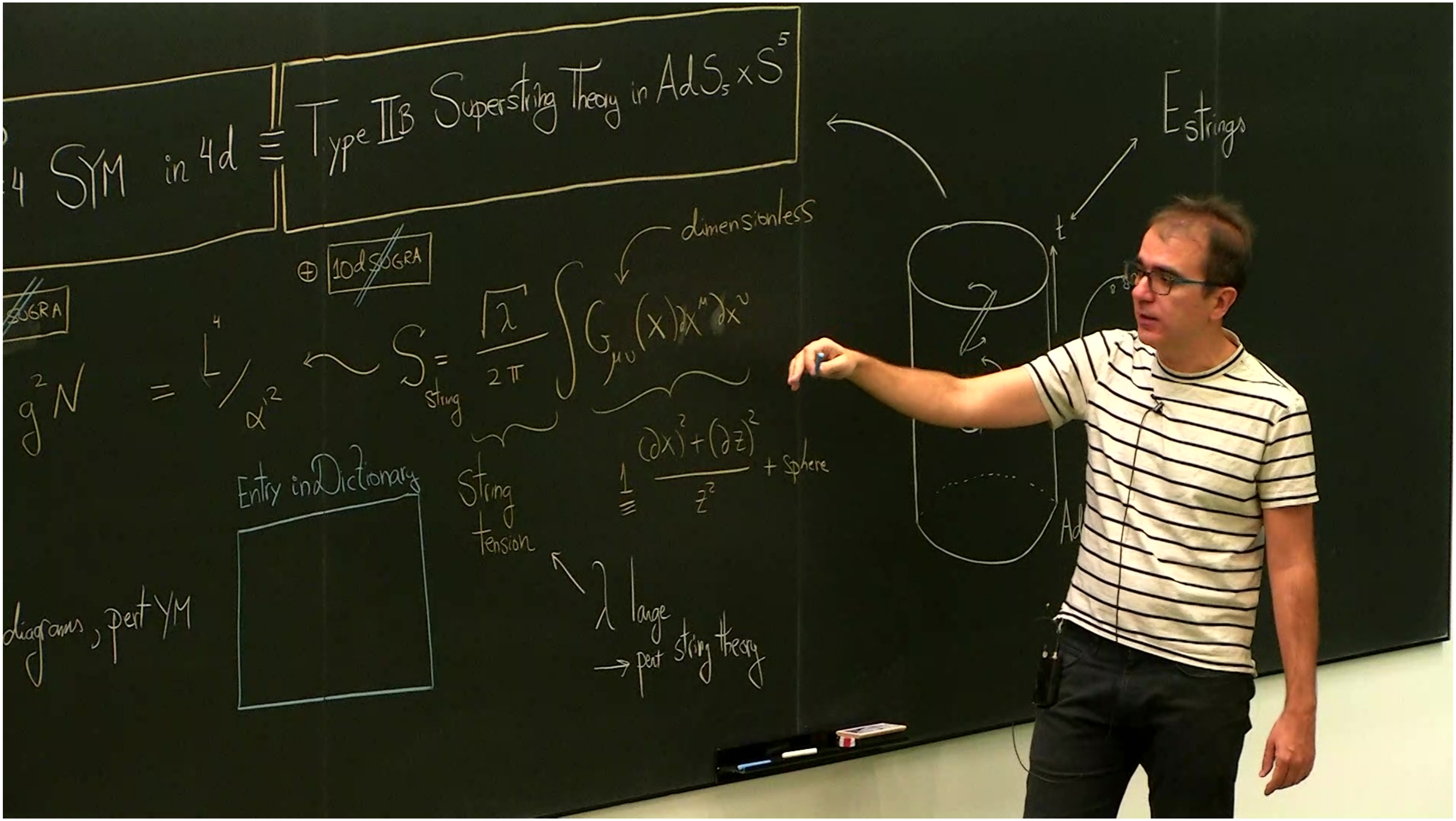
AdS/CFT :
N=4 SYM in 4d ≡ Type IIB Superstring Theory in AdS5
⊕ 10D SUGRA
⊕ 10d SUGRA
λ = g²N = L⁴/α'²
λ small
→ few diagrams, pert YM
O_A = |Spin chain state⟩
Energy (chain) = Δ
E in R×S³
RE = Δ
Entry in Dictionary
large
→ pert string theory

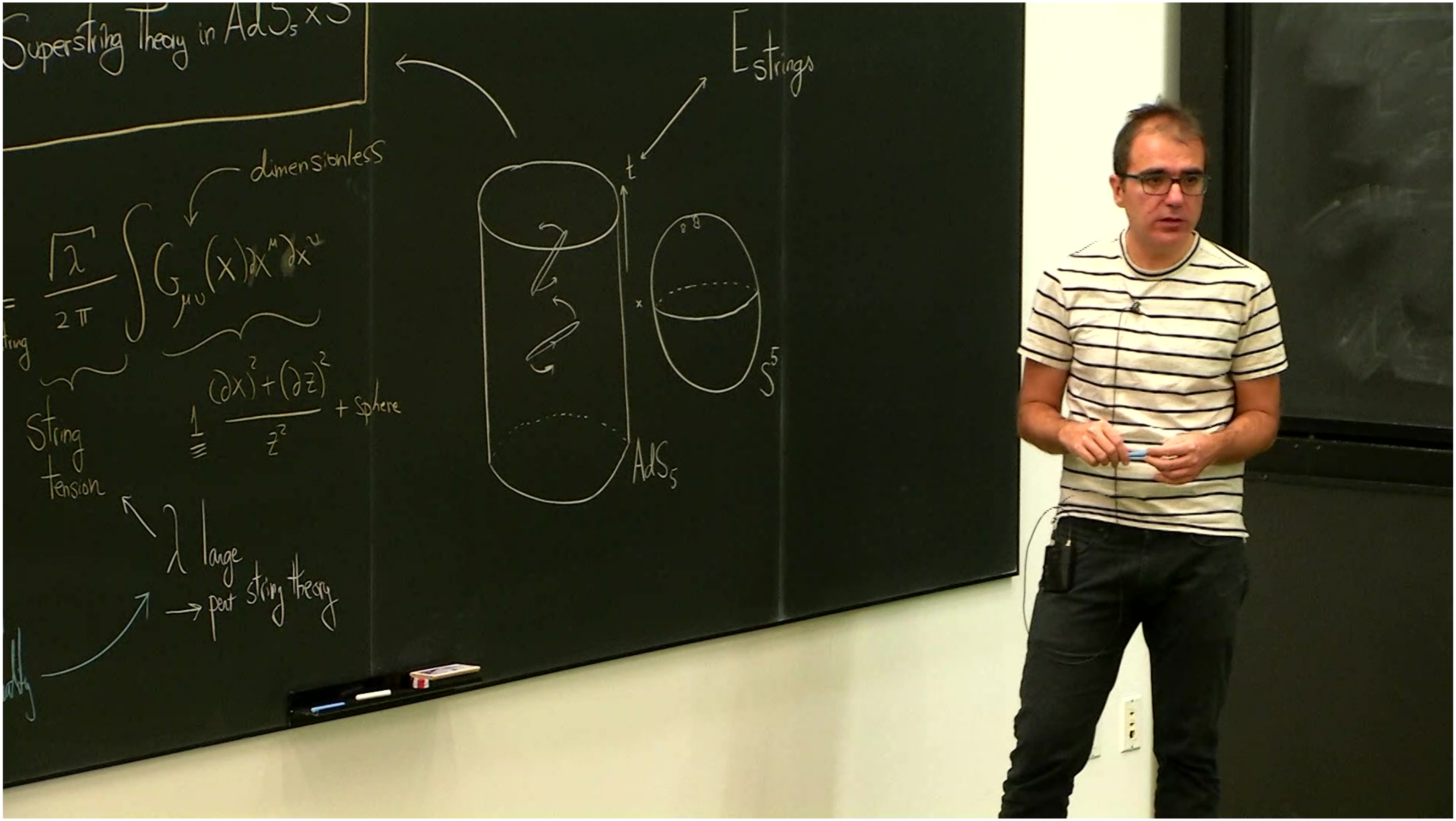

AdS/CFT :
N=4 SYM in 4d ≡ Type IIB Superstring Theory in AdS5 x S5
⊕ 10D SUGRA
⊕ 10d SUGRA
λ = g²N = L⁴/α'²
S_string = √λ/2π ∫ G_μν(x) ∂x^μ ∂x^ν
dimensionless
1/z² ((∂x)² + (∂z)²) + sphere
String tension
Entry in Dictionary
λ small
→ few diagrams, pert YM
λ large
→ pert string theory
| Spin chain state⟩
(chain) = Δ
t
AdS5

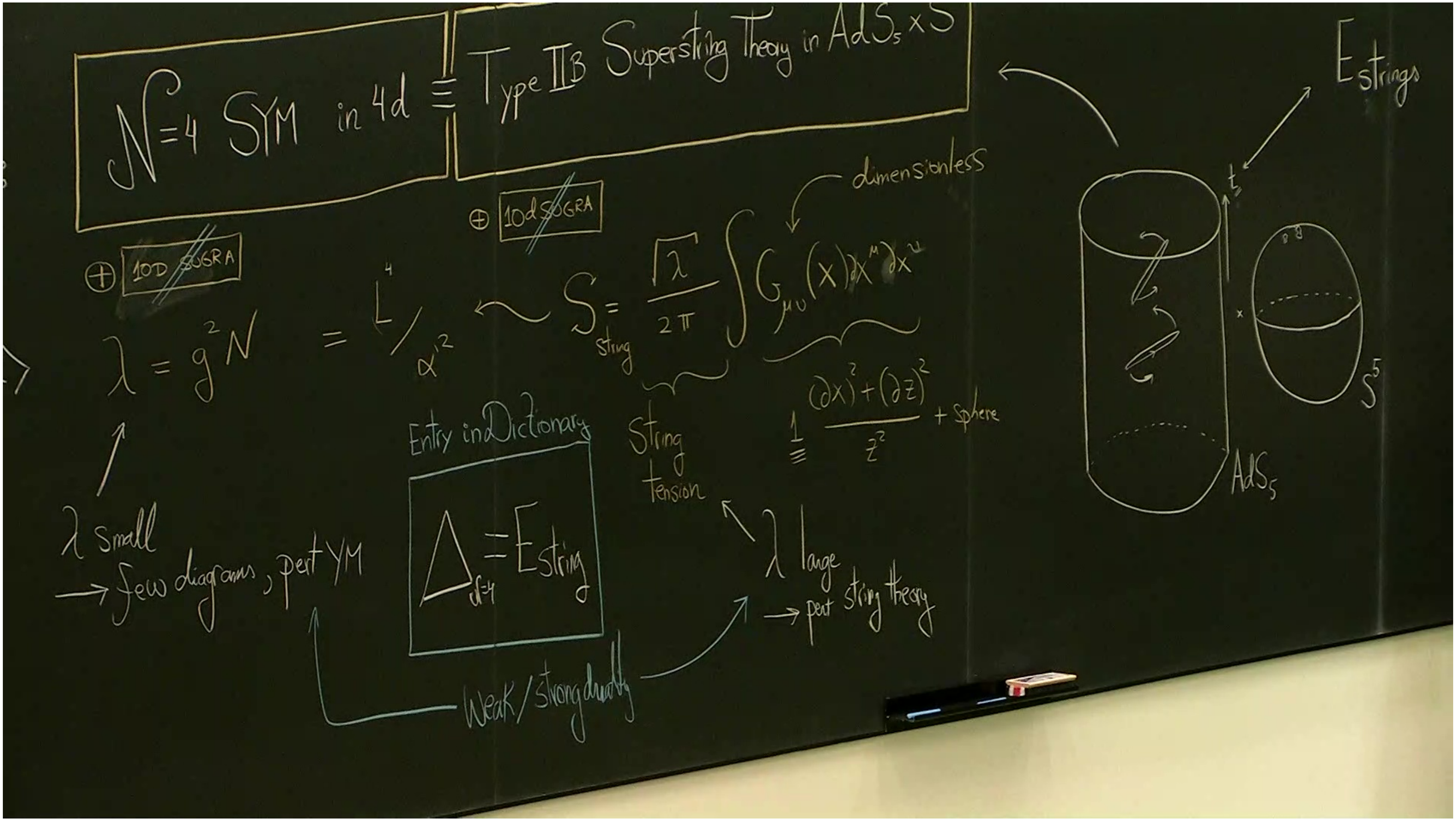

AdS/CFT :
N=4 SYM in 4d ≡ Type IIB Superstring Theory in AdS
⊕ 10D SUGRA
⊕ 10d SUGRA
λ = g²N = L⁴/α'²
S string = √λ / 2π ∫ G μν (x) ∂x^μ
String tension
O A = |Spin chain state⟩
E in R×S^D
RE = Δ
N=4 in R×S^d
Energy (chain) = Δ
λ small
→ few diagrams, pert YM
Entry in Dictionary
λ large
→ pert string

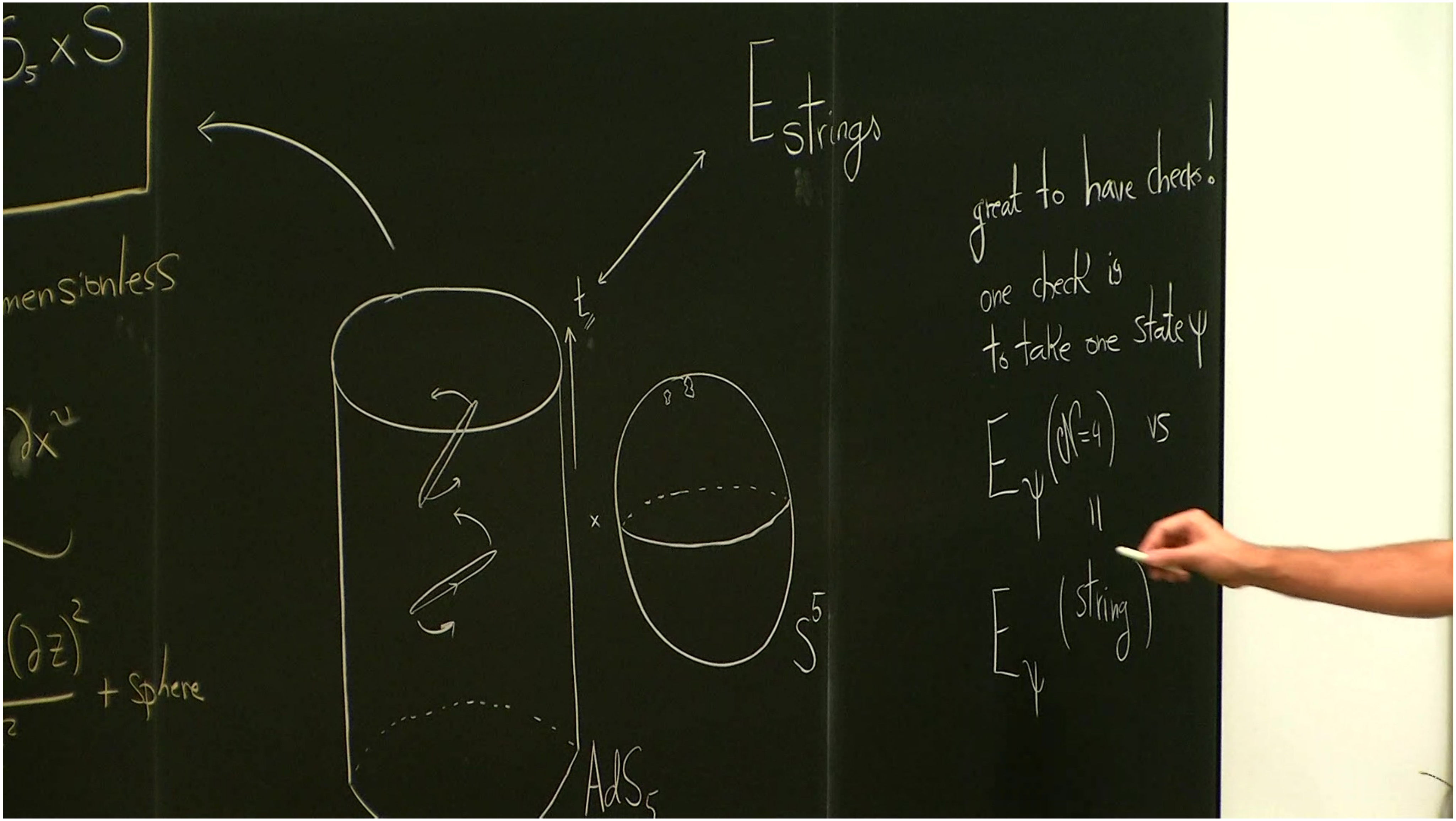


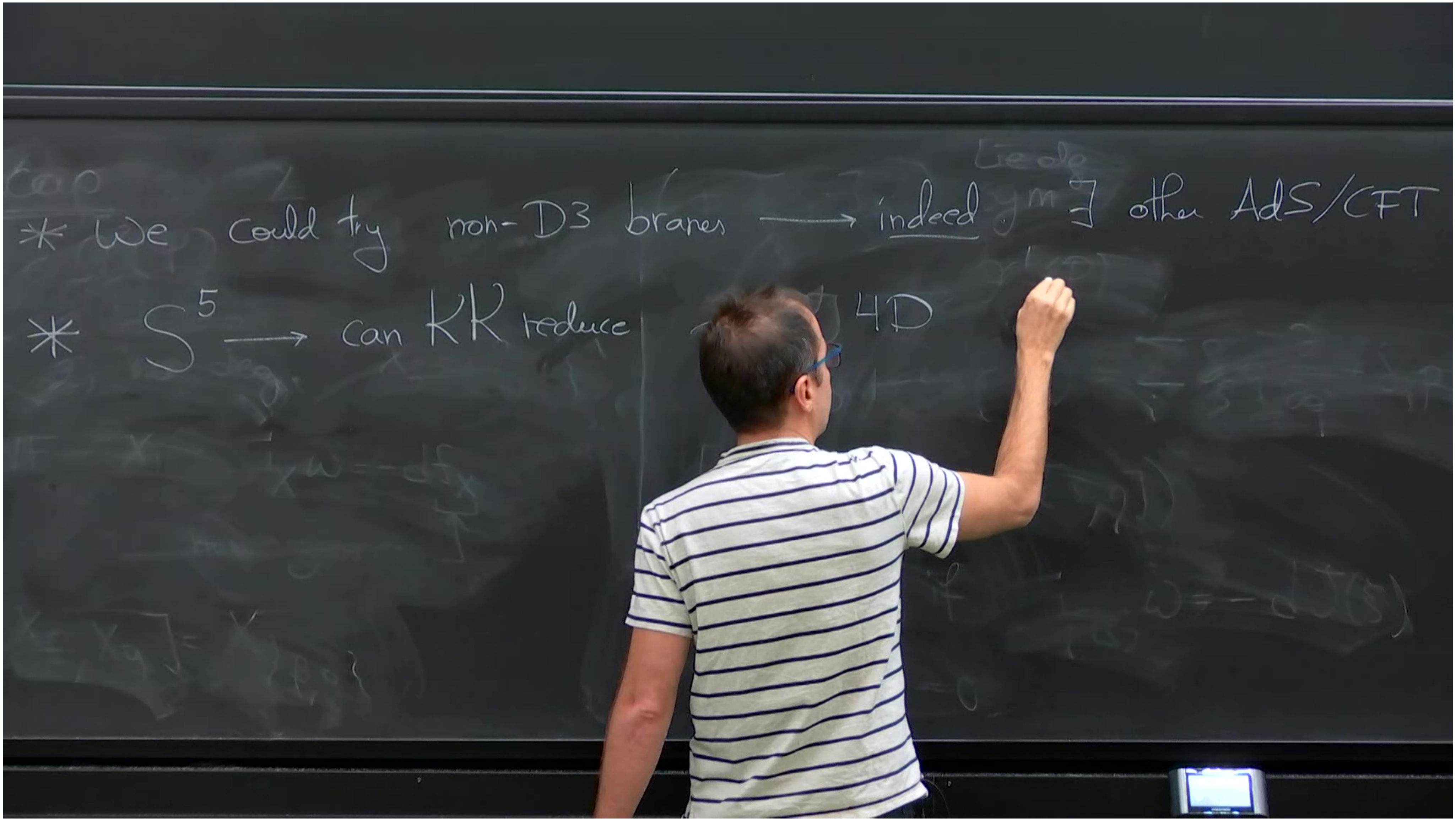
FT :
N=4 SYM in 4d ≡ Type IIB Superstring Theory in AdS5 x S5
⊕ 10D SUGRA
⊕ 10d SUGRA
dimensionless
λ = g2N = L4/α'2 ~ S string
Entry in Dictionary
state⟩
λ small
→ few diagrams, pert YM
+ sphere
theory
t
AdS5

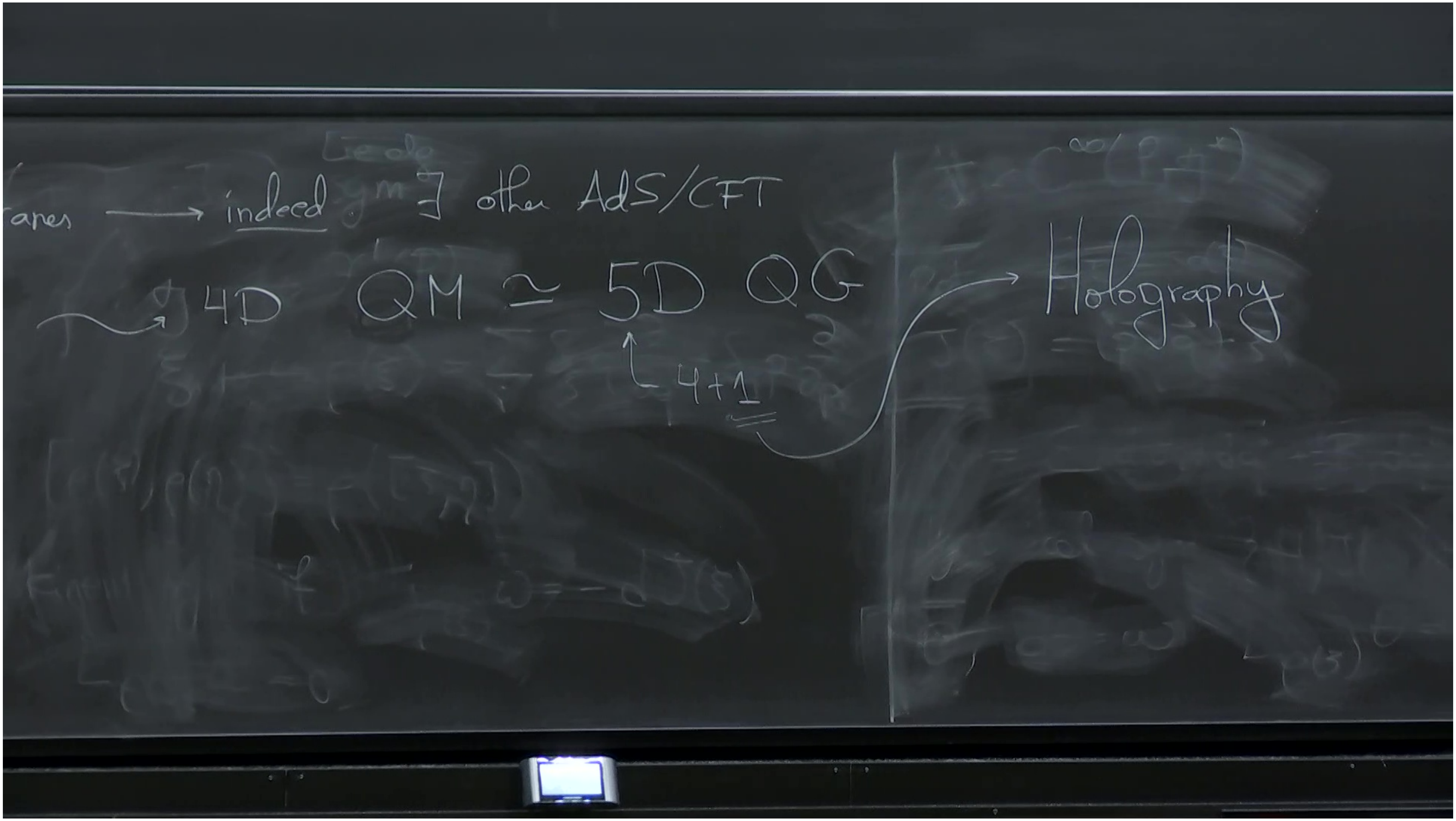

4 SYM in 4d ≡ Type IIB Superstring Theory in AdS5 x S5
10d SUGRA
SUGRA
dimensionless
g2N = L4/α'2 ~ Sstring = √λ/2π ∫ Gμν(x)∂xμ∂xν
(∂x)2 + (∂z)2 / z2 + sphere
String tension
Entry in Dictionary
λ large
→ pert string theory
diagrams, pert YM
Estrings
t
z

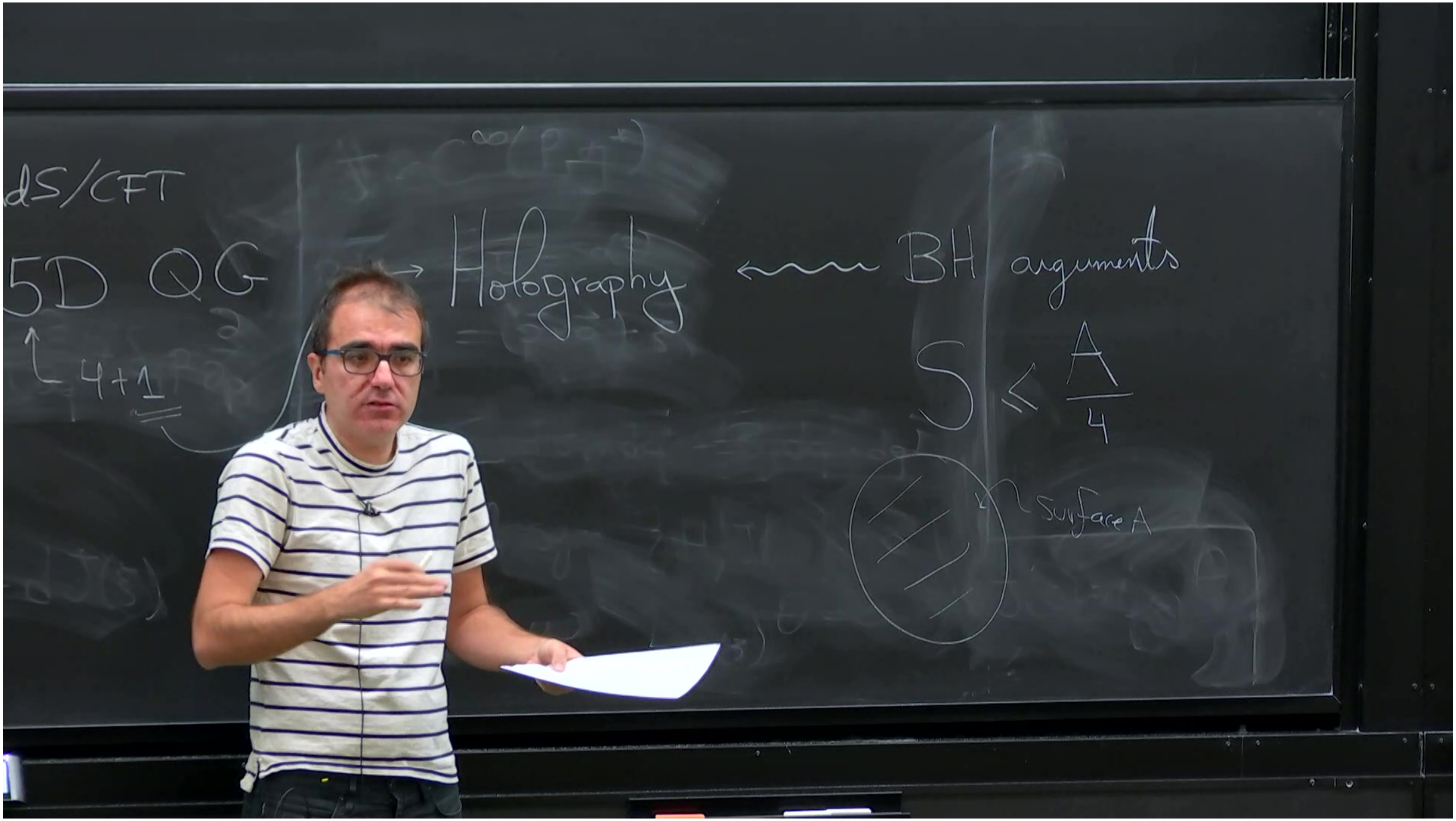

Superstring Theory in AdS5 x S
dimensionless
E strings
t
S5
AdS5
String tension
+ sphere
λ large
pert string theory

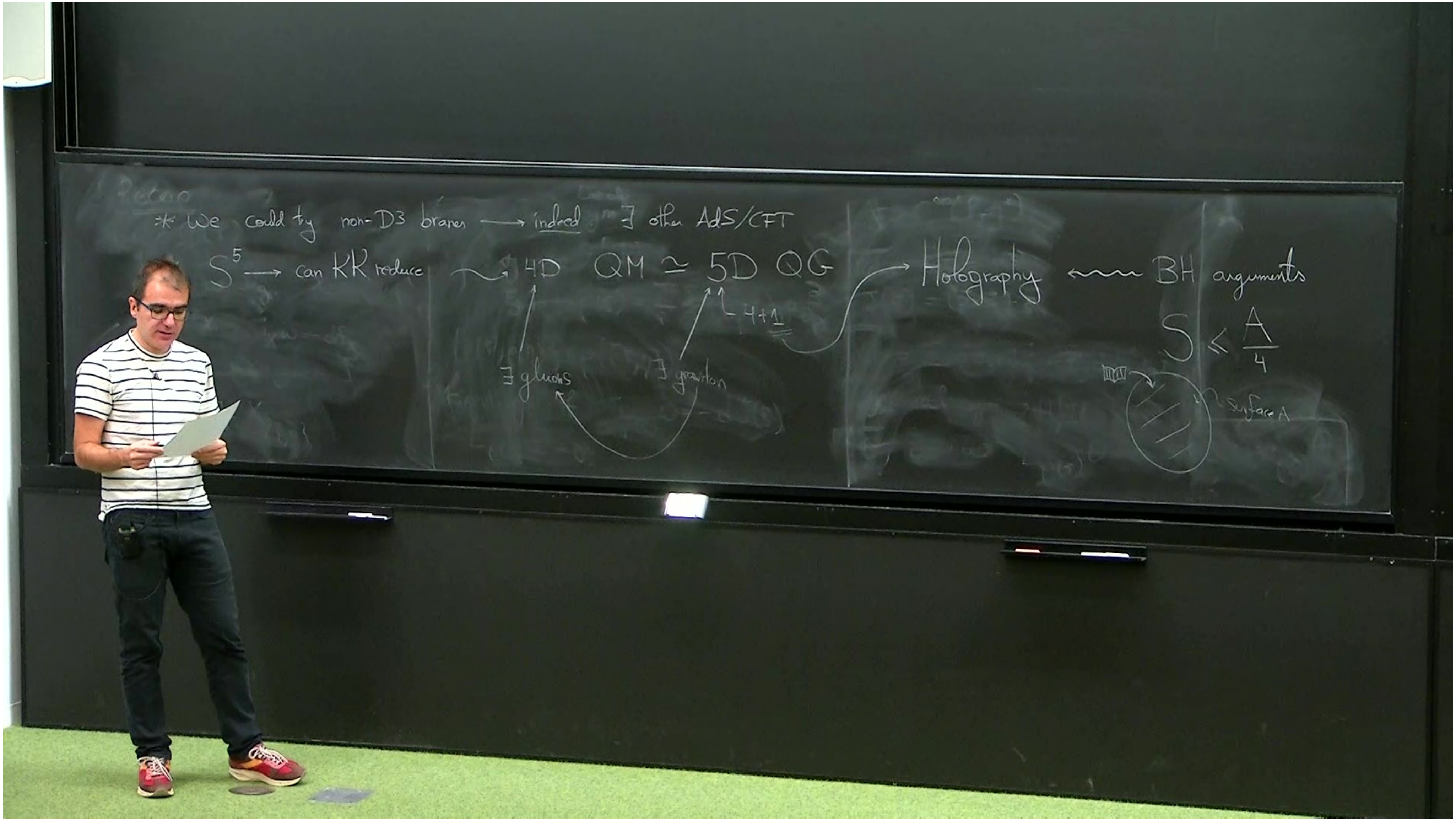

N=4 SYM in 4d ≡ Type IIB Superstring Theory in AdS5 x S
⊕ 10D SUGRA
⊕ 10d SUGRA
λ = g²N = L⁴/α'²
S string = √λ / 2π ∫ Gμν(x) ∂x^μ ∂x^ν
dimensionless
String tension
1 ≡ ((∂x)² + (∂z)²) / z² + sphere
λ small
→ few diagrams, pert YM
Entry in Dictionary
Δ d=4 = E string
λ large
→ pert string theory
Weak / strong duality
E strings
t
AdS5
S5

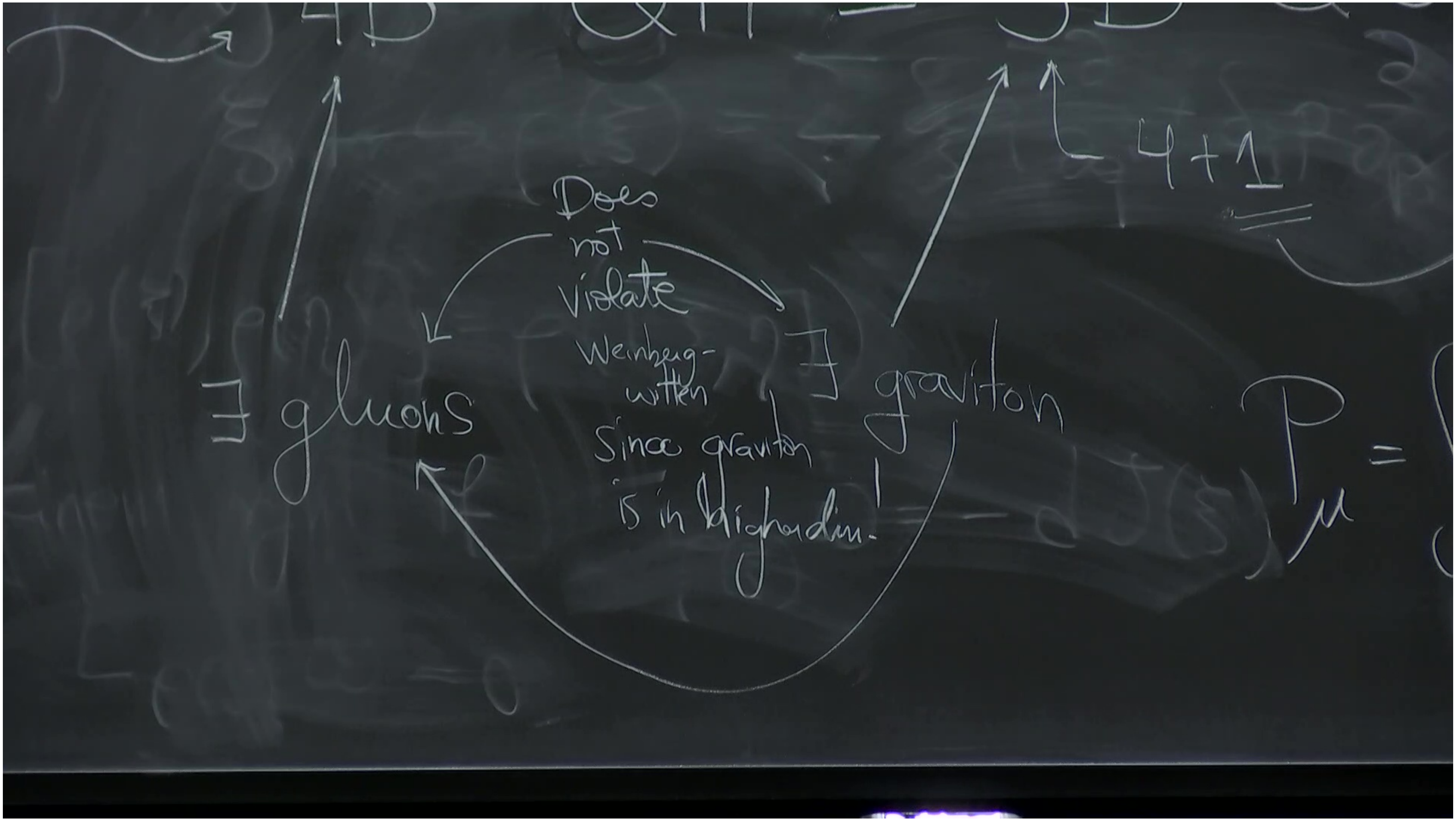

E strings
great to have checks!
one check is
to take one state ψ
E_ψ (N=4) vs
=
E_ψ (string)
mensionless
+ sphere
AdS_5
S^5

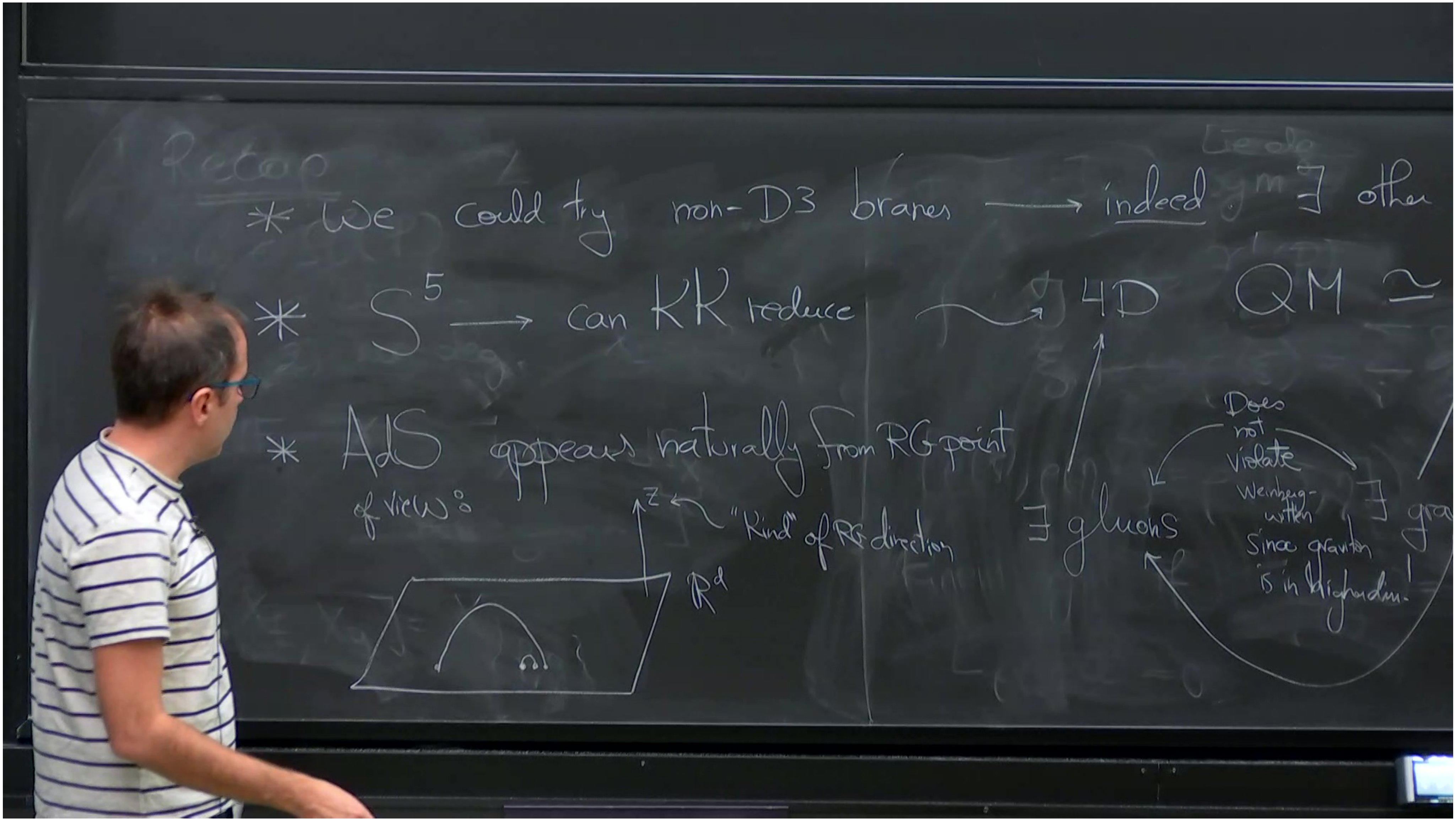

* We could try non-D3 branes ⟶ indeed ∃ other AdS/CFT
* S^5 ⟶ can KK reduce 4D

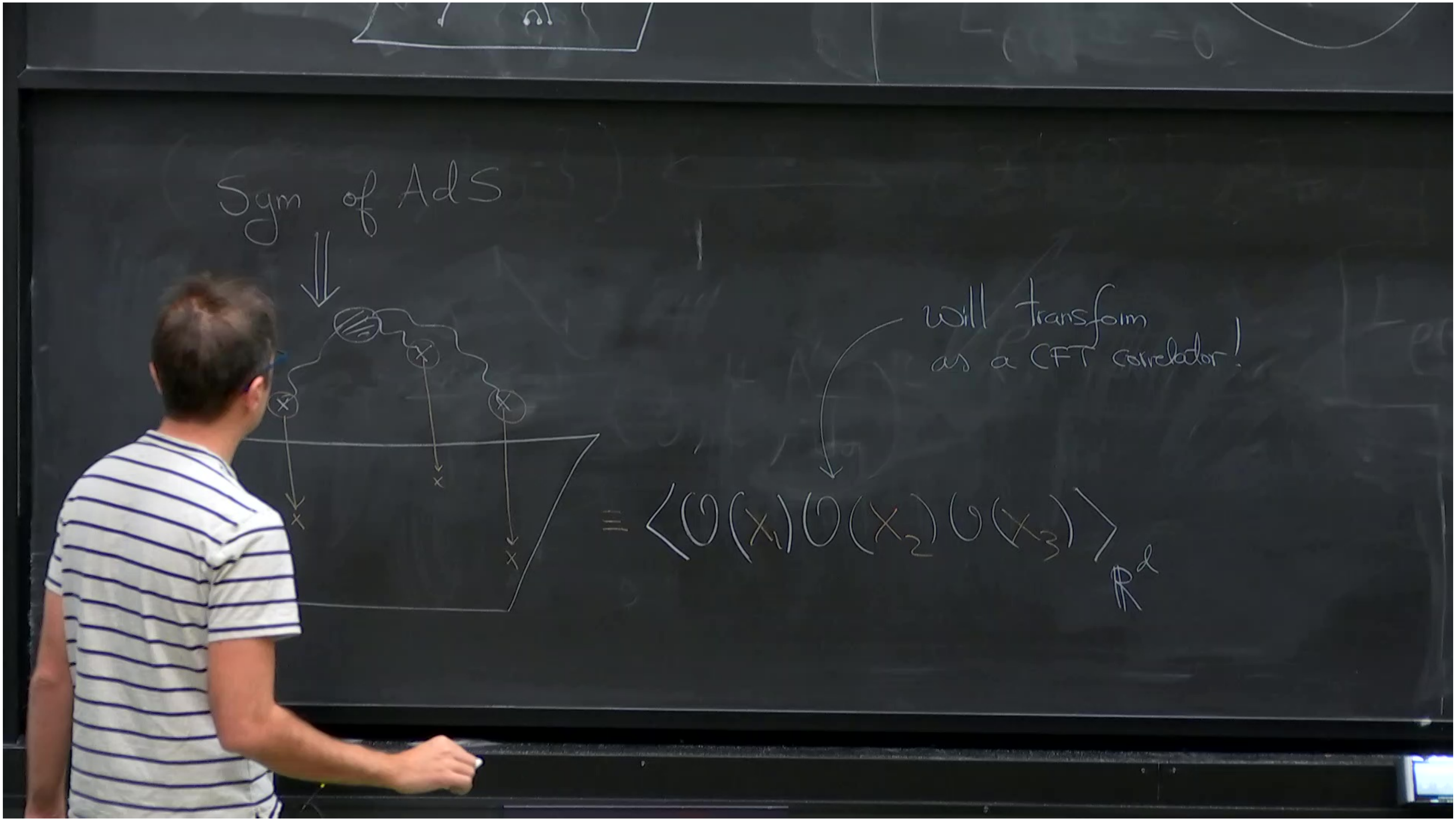

anes → indeed ∃ other AdS/CFT
4D QM ≃ 5D QG
4+1
Holography

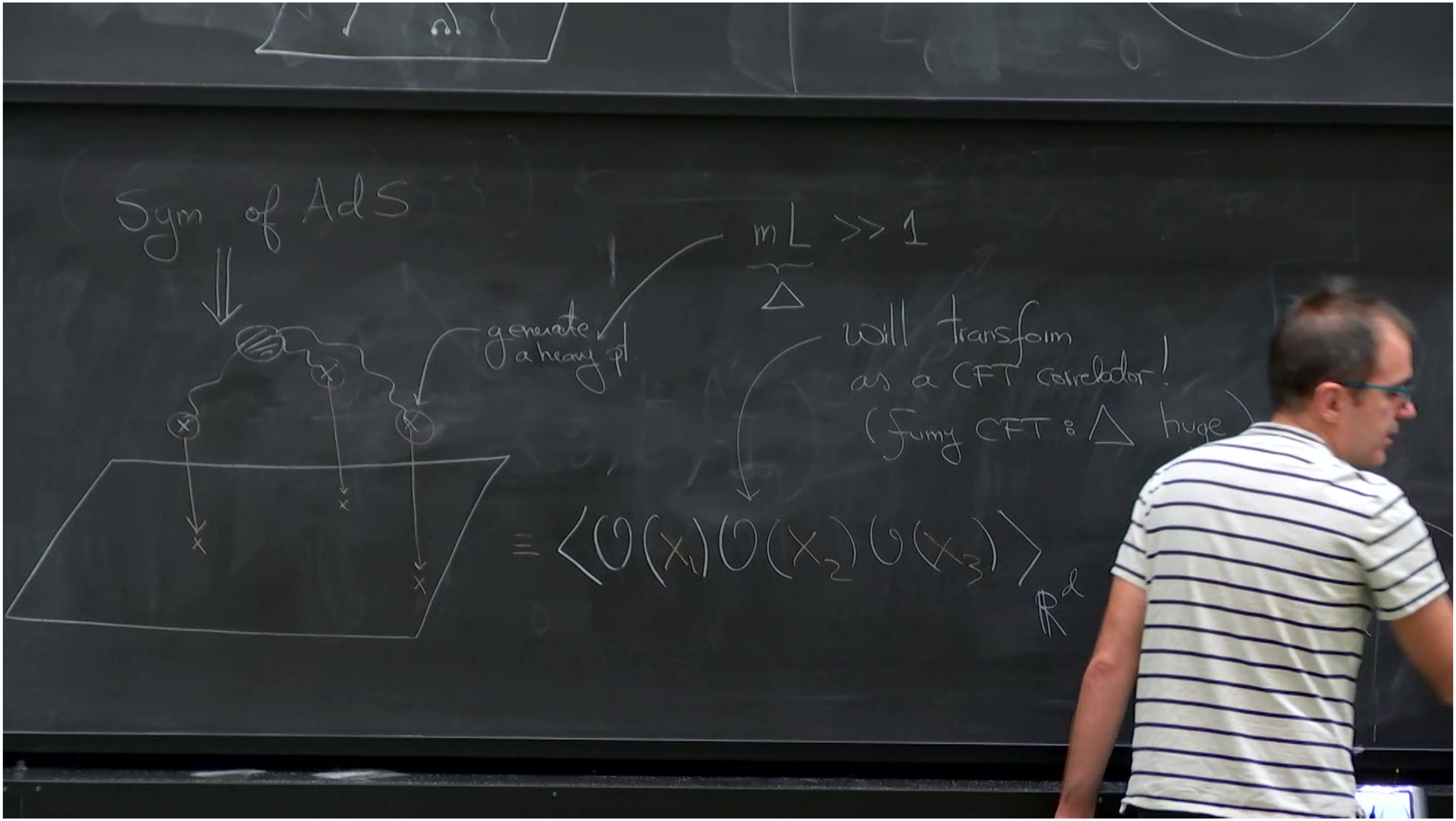

AdS/CFT
5D QG
4+1
Holography
BH arguments
S ≤ A/4
Surface A

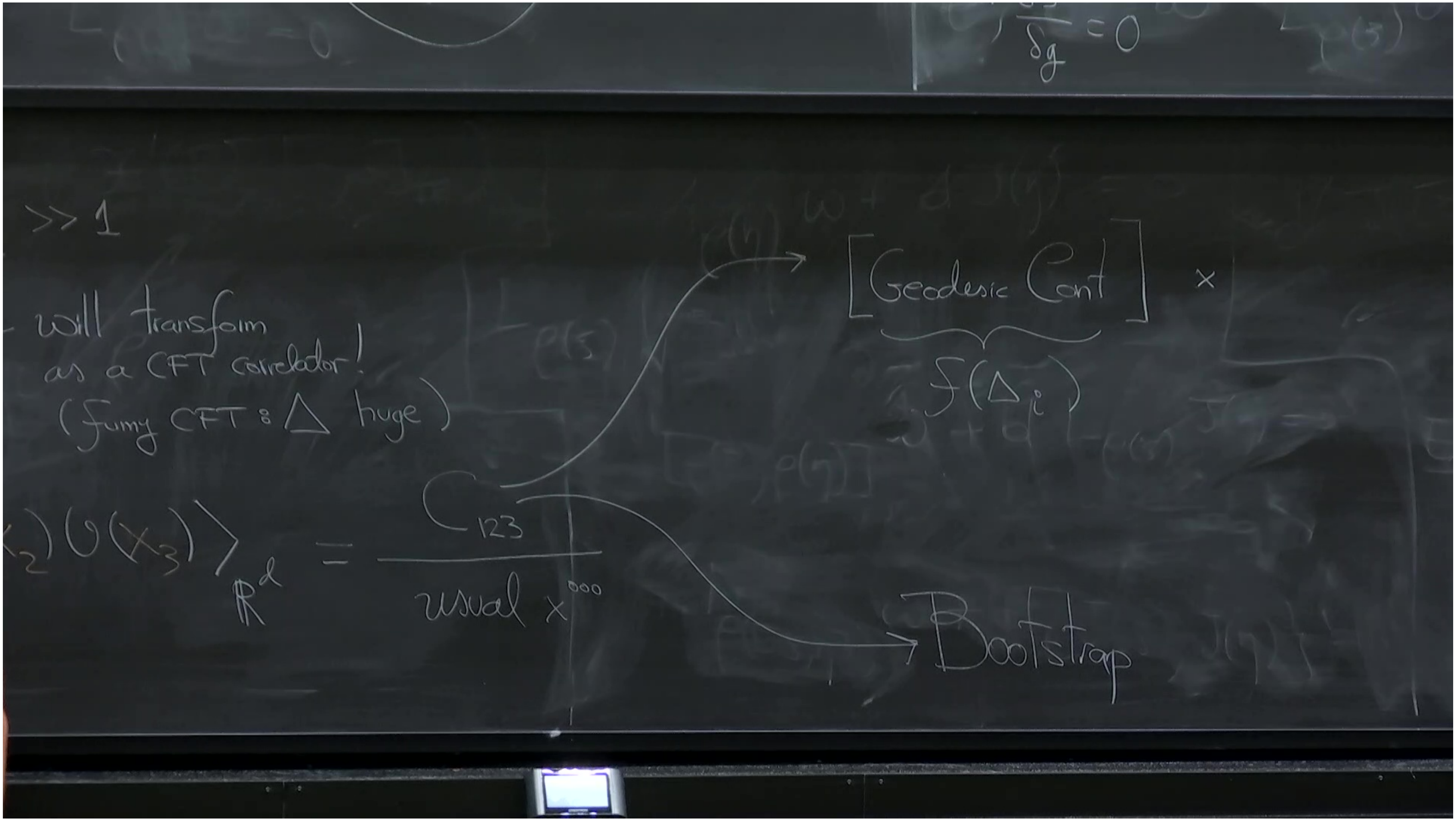

* We could try non-D3 branes → indeed ∃ other AdS/CFT
S^5 → can KK reduce
4D QM ≃ 5D QG
4+1
∃ gluons
∃ graviton
Holography
BH arguments
S ≤ A/4
surface A

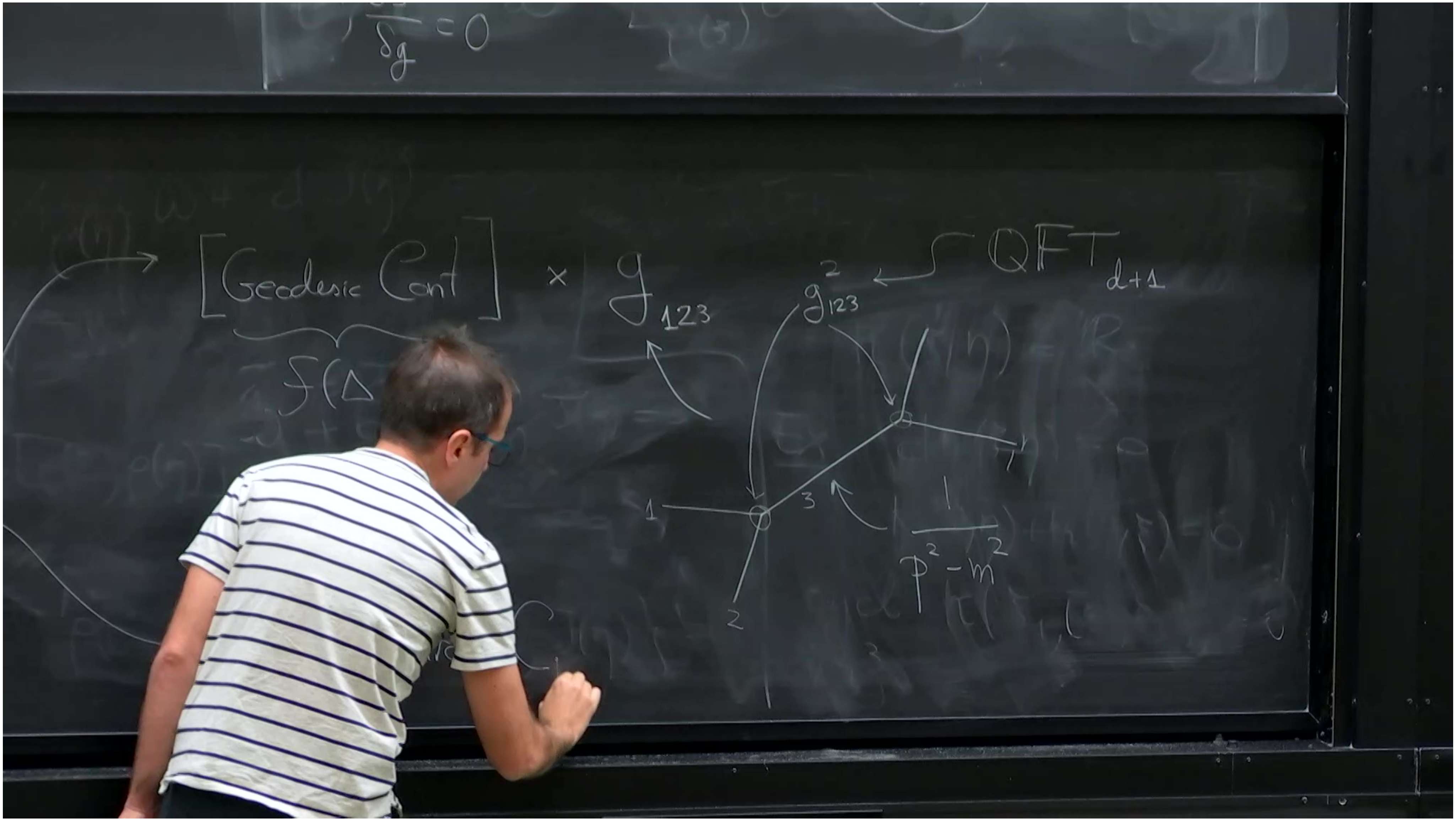

4D
QFT
5D
4+1
Does
not
violate
Weinberg-
witten
Since graviton
is in higher dim!
∃ gluons
∃ graviton
P_μ =


Recap
* We could try non-D3 branes → indeed ∃ other
* S^5 → can KK reduce → ∃ 4D QM ≃
* AdS appears naturally from RG point of view:
z
"Kind" of RG direction
R^d
∃ gluons
Does not violate Weinberg-witten since graviton is in higher dim.!
∃

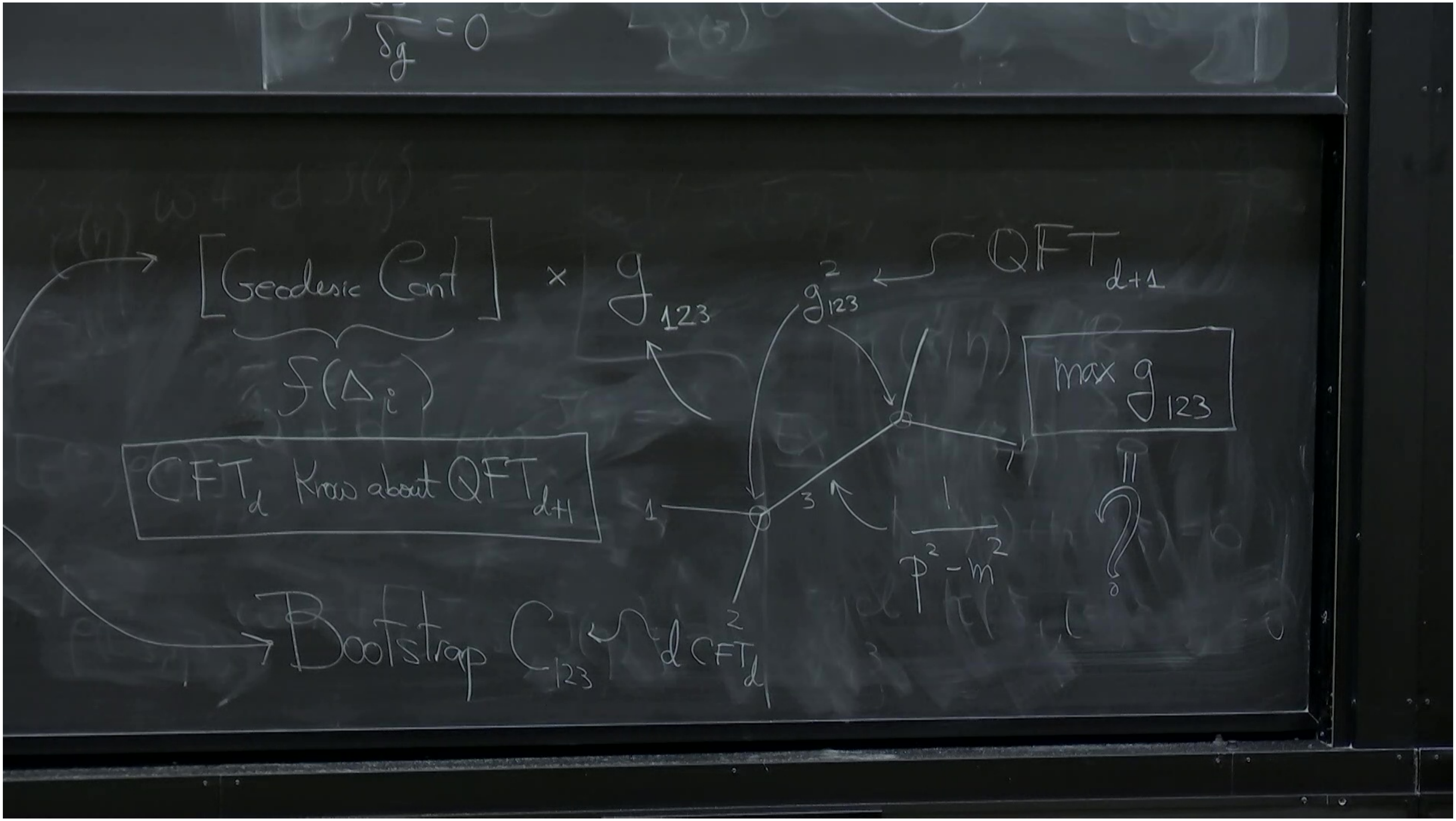

Sym of AdS
will transform
as a CFT correlator!
$= \langle O(x_1) O(x_2) O(x_3) \rangle_{\mathbb{R}^d}$


Sym of AdS
generate a heavy pt
$\underbrace{mL}_{\Delta} \gg 1$
Will transform as a CFT correlator!
(funny CFT: Δ huge)
$= \langle \mathcal{O}(x_1)\mathcal{O}(x_2)\mathcal{O}(x_3) \rangle_{\mathbb{R}^d}$

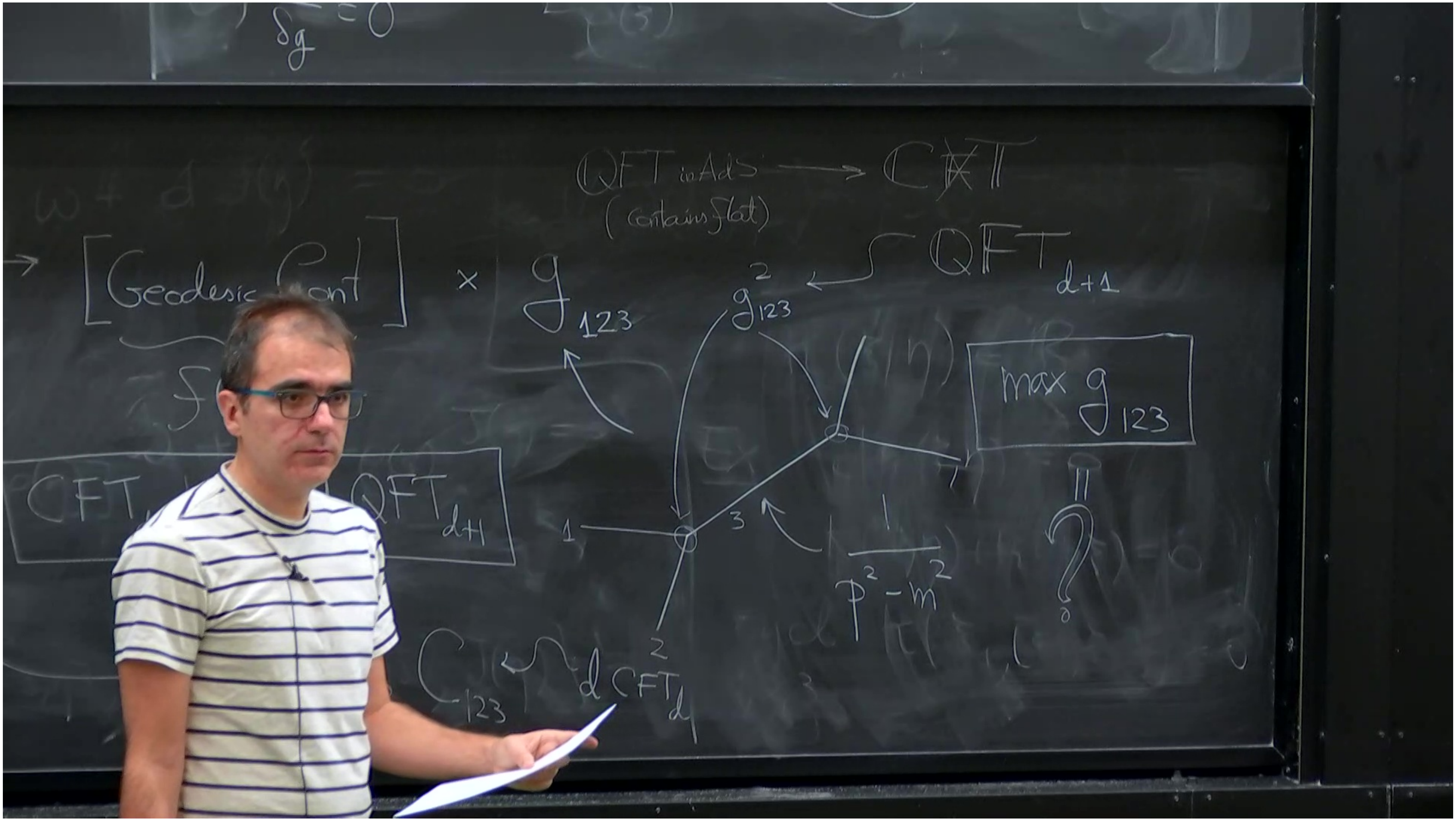

>> 1
will transform
as a CFT correlator!
(funny CFT: Δ huge)
$_2) O(x_3) \rangle_{\mathbb{R}^d} = \frac{C_{123}}{\text{usual } x^{\cdots}}$
[Geodesic Cont] ×
$f(\Delta_i)$
Bootstrap



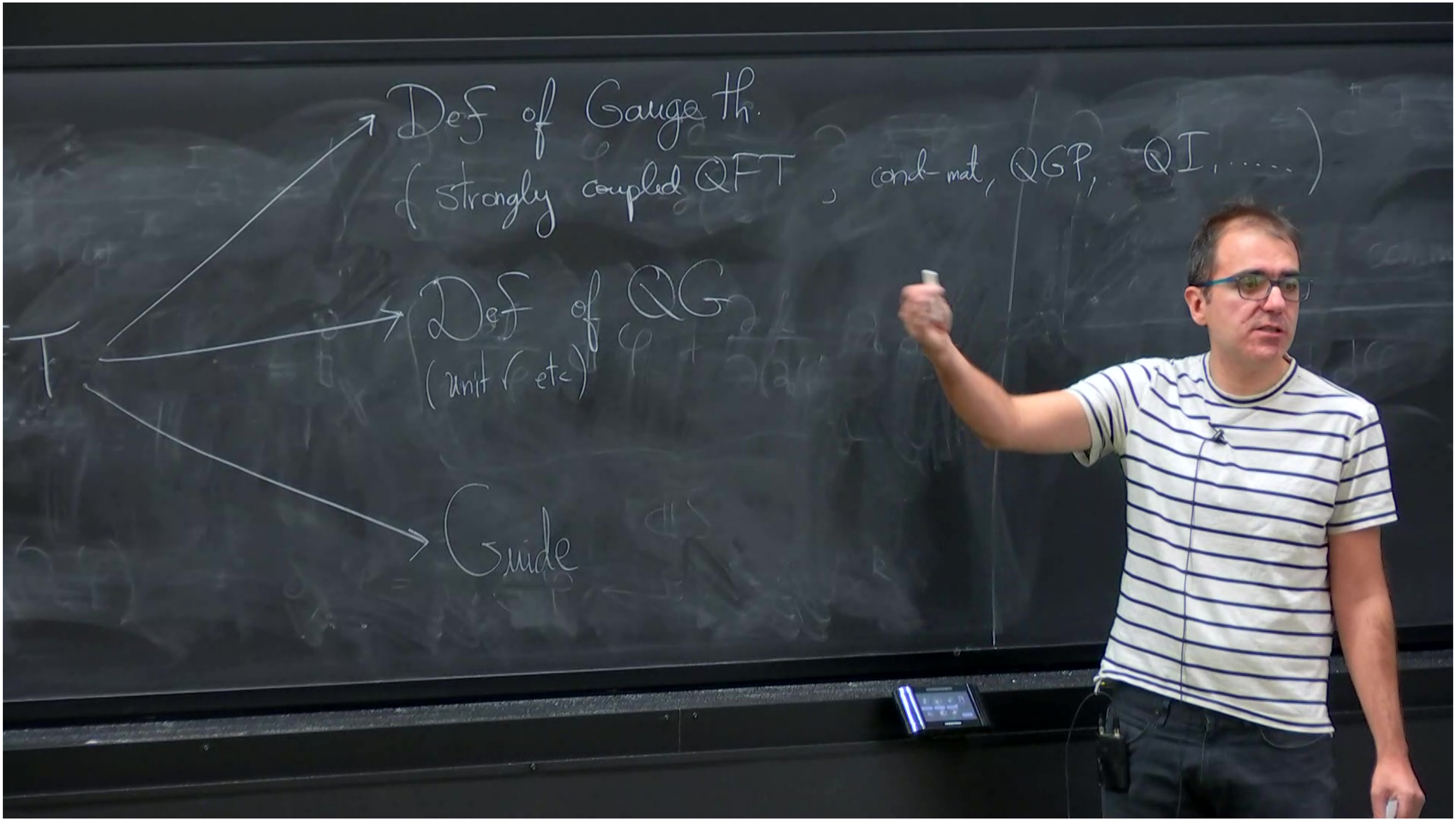
[Geodesic Cont] × g 123
f(Δ
g² 123
QFT d+1
1
2
3
1/(p² − m²)

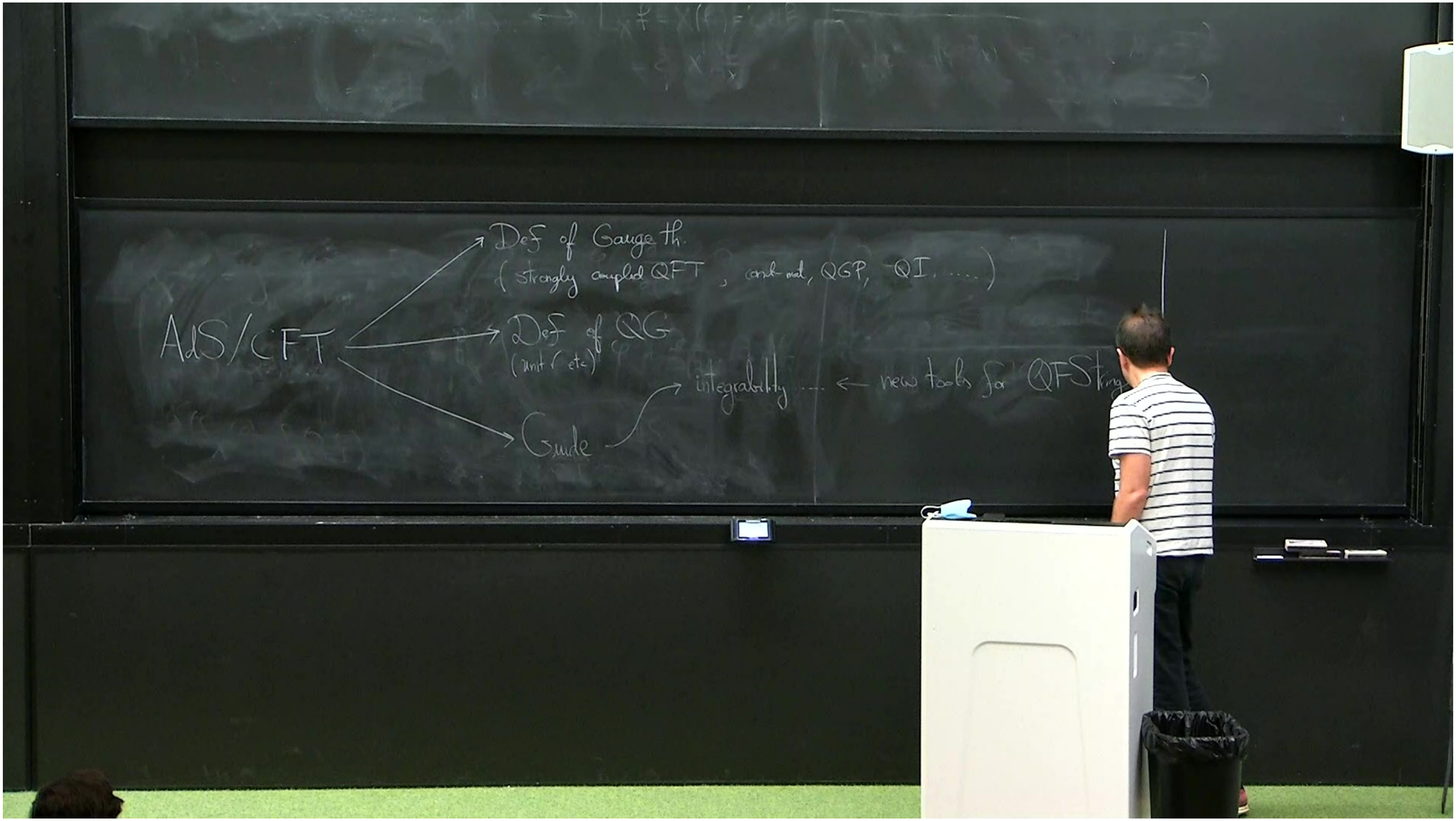


δg = 0
[Geodesic Cont] × g123
f(Δi)
g²123
QFTd+1
max g123
CFTd Know about QFTd+1
1
3
2
1/(p² − m²)
?
Bootstrap C123
d CFTd

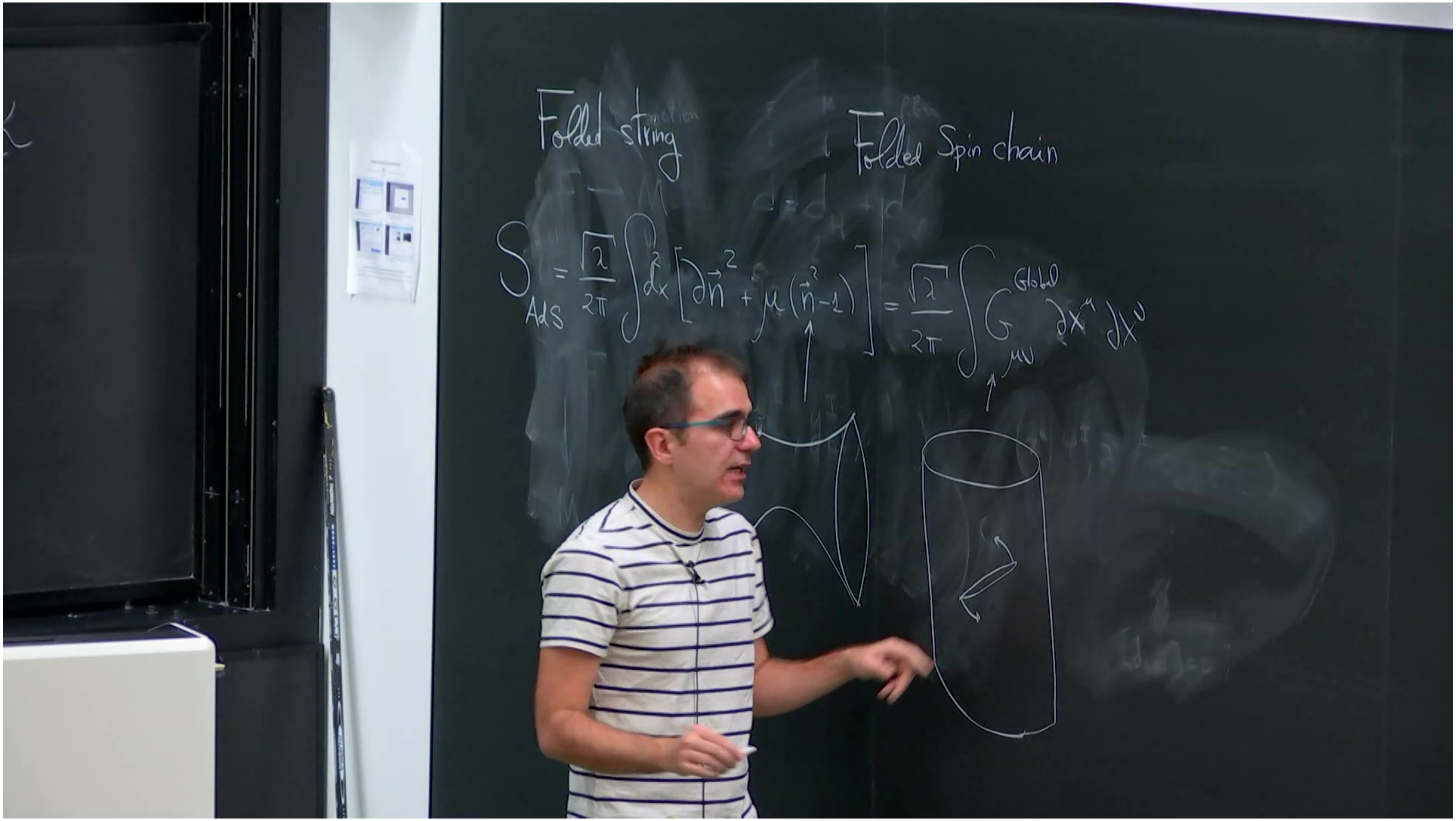


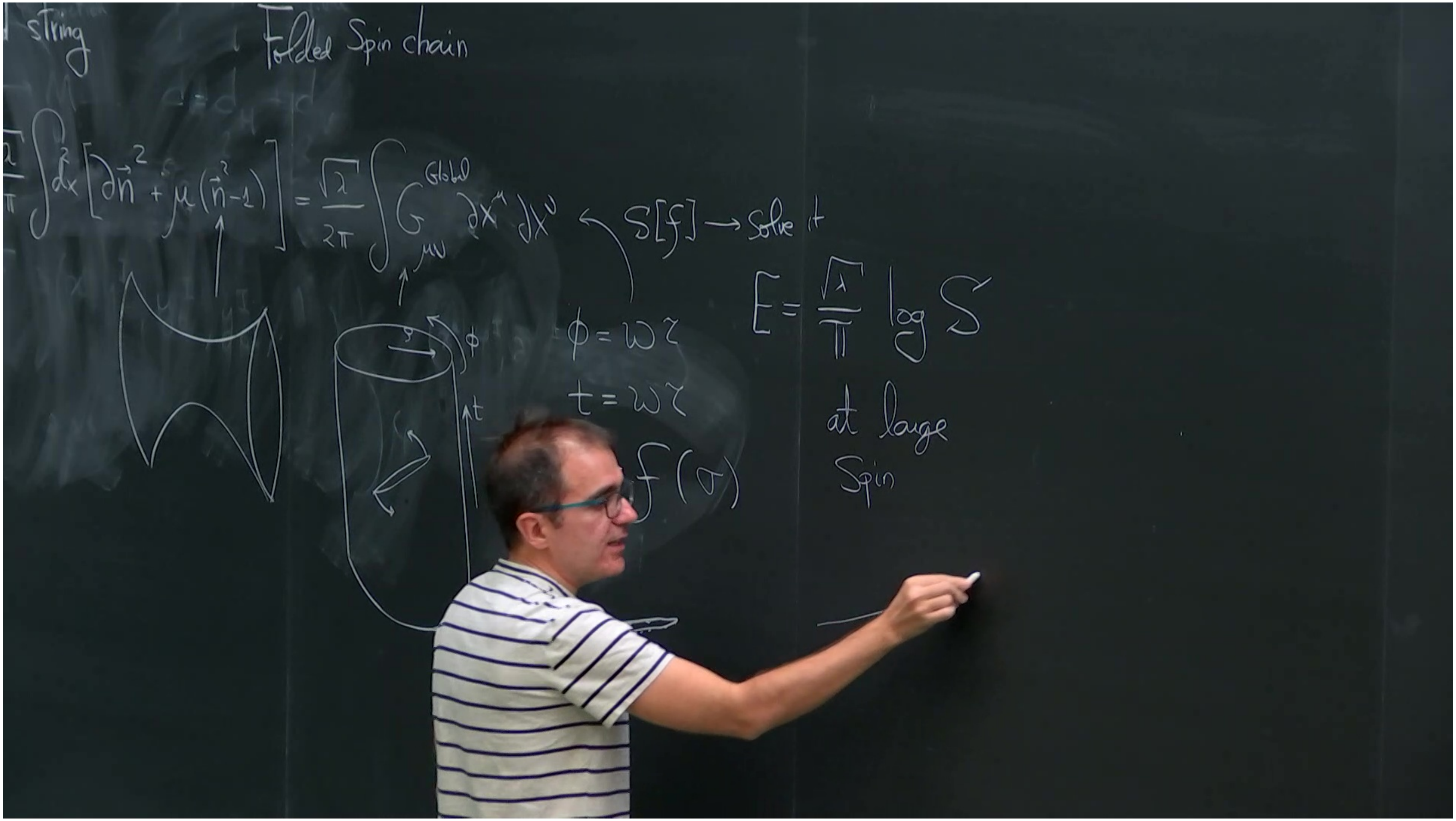
QFT in AdS → CFT
(contains flat)
[Geodesic Cont] × g_{123}
g^2_{123} ↩ QFT_{d+1}
max g_{123}
CFT_d
QFT_{d+1}
1
2
3
$\frac{1}{p^2-m^2}$
C^2_{123} ↩ CFT_d

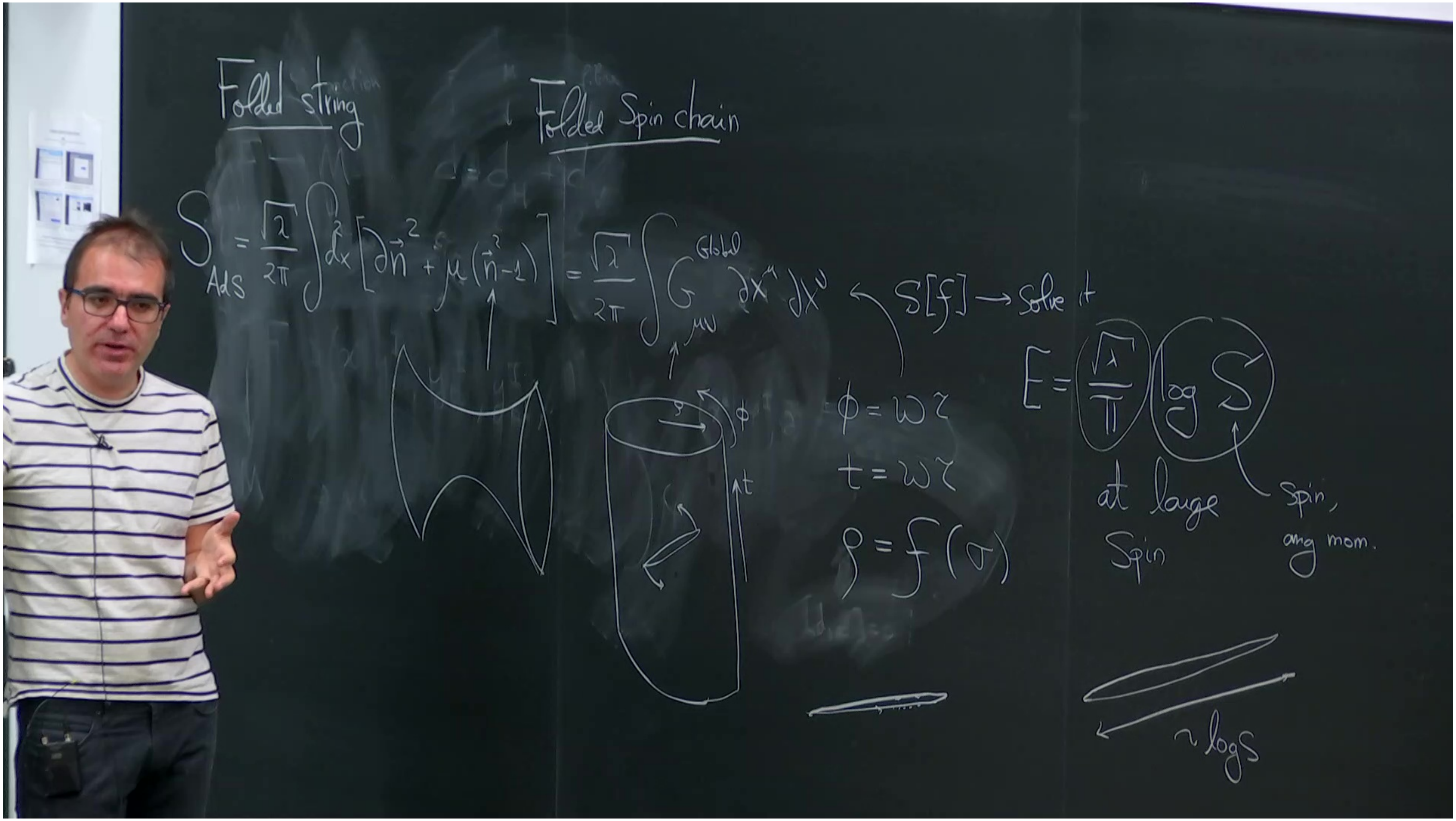

Def of Gauge th.
(strongly coupled QFT , cond-mat, QGP, QI, ...)
Def of QG
Guide

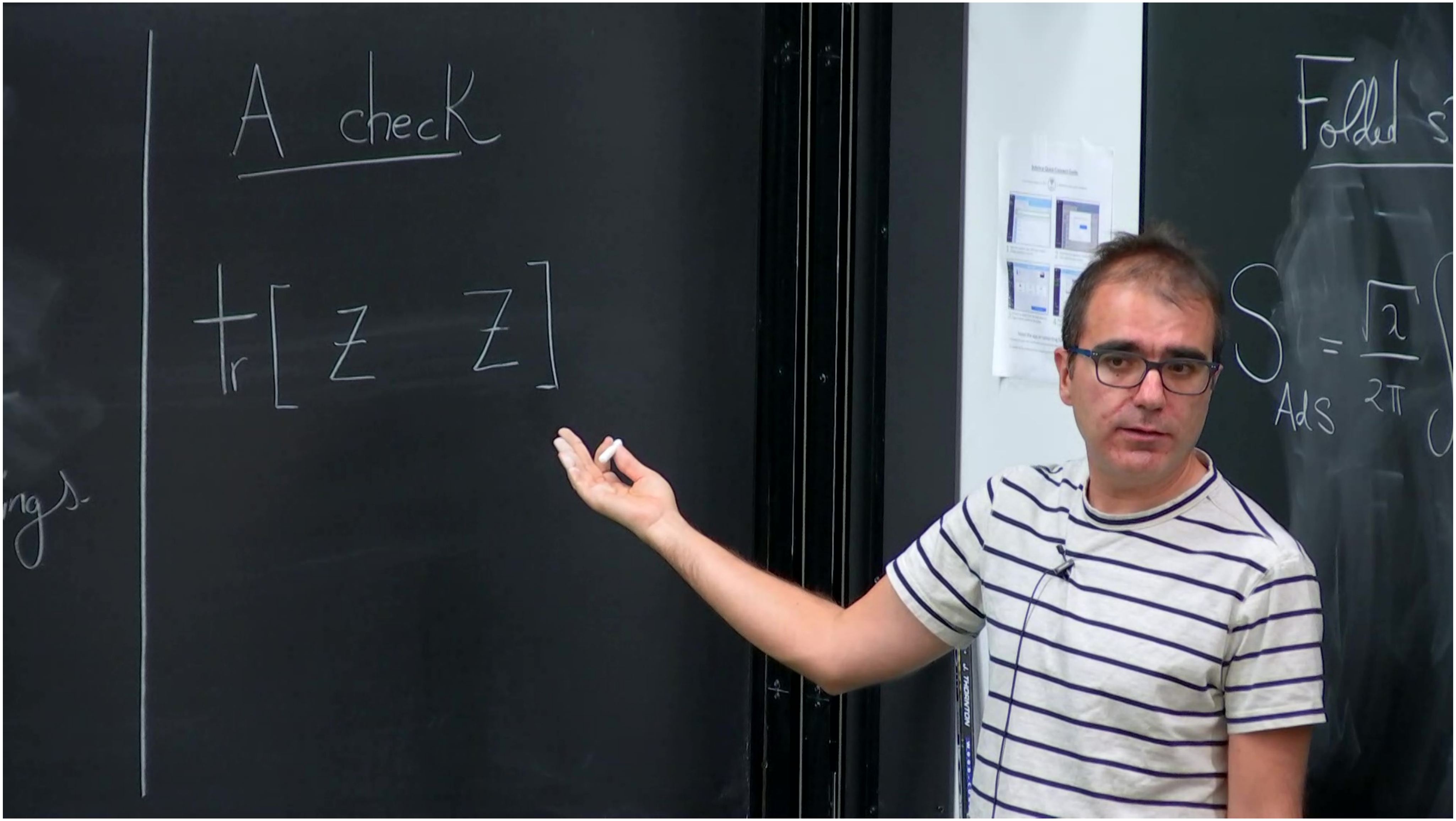


Def of Gauge th.
QGP, QI, ...
AdS/CFT
Def of QG
Guide
integrability .... ← new tools for


Folded string
Folded Spin chain
$S_{AdS} = \frac{\sqrt{\lambda}}{2\pi}\int d^2x\left[\partial\vec{n}^{\,2} + \mu(\vec{n}^{\,2}-1)\right] = \frac{\sqrt{\lambda}}{2\pi}\int G^{Global}_{\mu\nu}\,\partial x^{\mu}\,\partial x^{\nu}$


string
Folded Spin chain
Global
S[f] → Solve it
φ = ωτ
t = ωτ
E = √λ/π log S
at large Spin


Folded string
Folded Spin chain
Global
S[f] → Solve it
φ = ω τ
t = ω τ
ρ = f(σ)
at large Spin
spin, ang mom.
~ log S

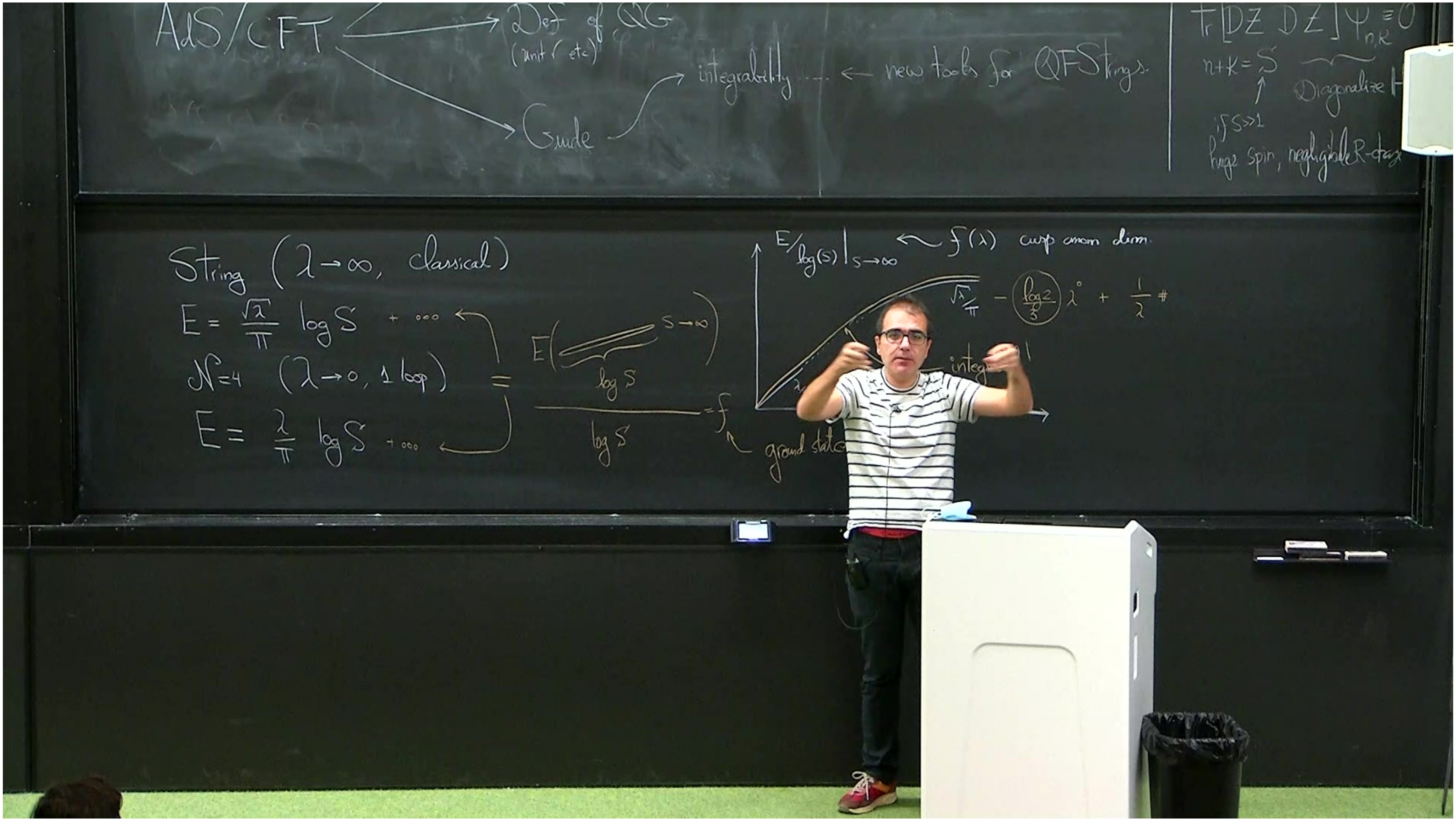

A check
tr[Z Z]
Folded s
$S_{AdS} = \frac{\sqrt{\lambda}}{2\pi}$

String ($\lambda \to \infty$, classical)

$$E = \frac{\sqrt{\lambda}}{\pi} \log S$$

$\mathcal{N}=4$ ($\lambda \to 0$, 1 loop)

$$E = \frac{\lambda}{\pi} \log S$$


AdS/CFT
Def of QG
(unit / etc)
integrability .... ← new tools for QFStrings.
Guide
Tr [DZ DZ] Ψ_{n,K} ≡ O
n+K = S
Diagonalize H
if S>>1
huge spin, negligible R-charge
String (λ→∞, classical)
E = √λ/π log S + ...
N=4 (λ→0, 1 loop)
E = λ/π log S + ...
E(S→∞)
log S
log S
= f
ground state
E/log(S) |S→∞ ← f(λ) cusp anom dim.
√λ/π − (log 2/3) λ° + 1/λ #