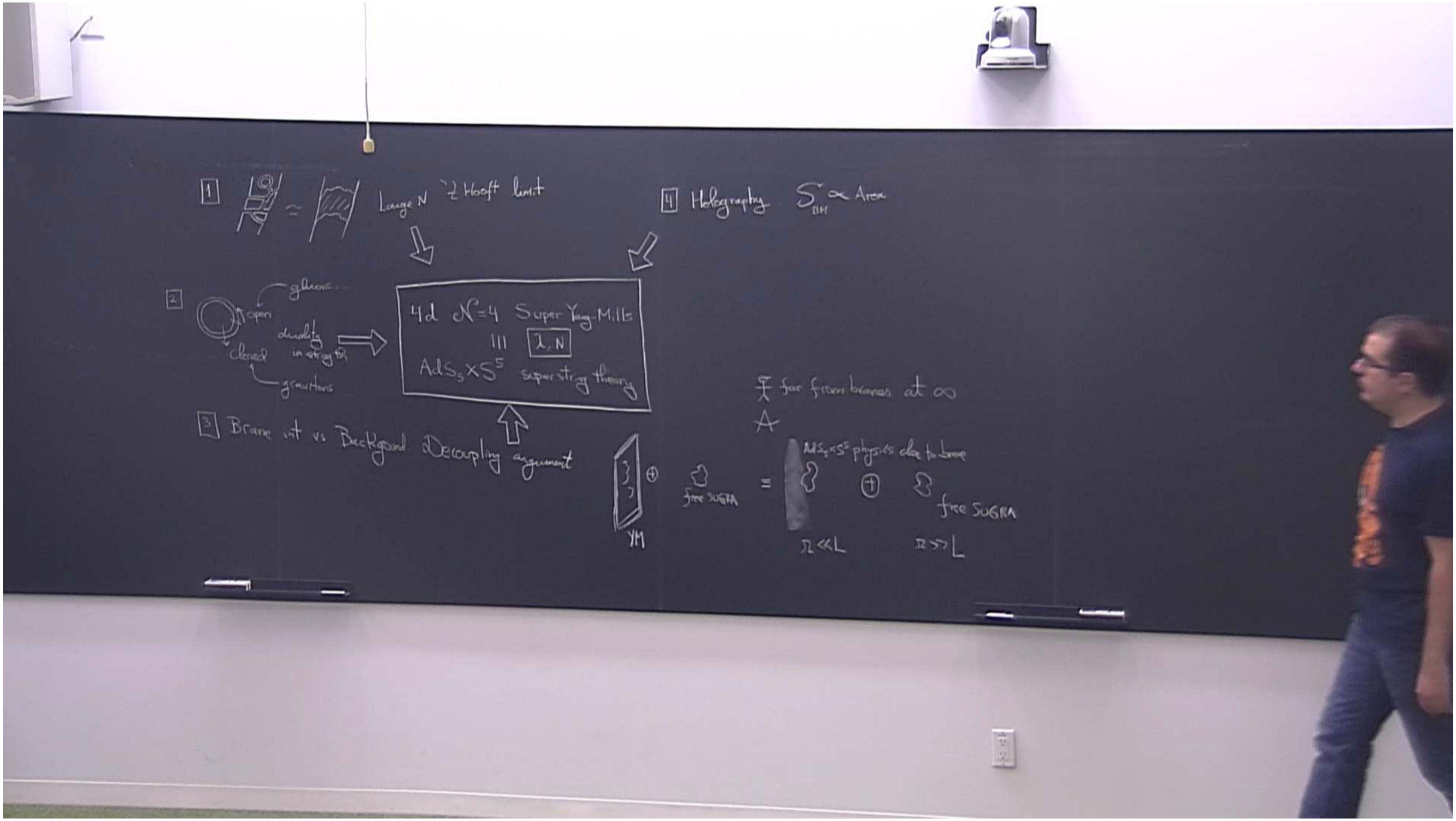
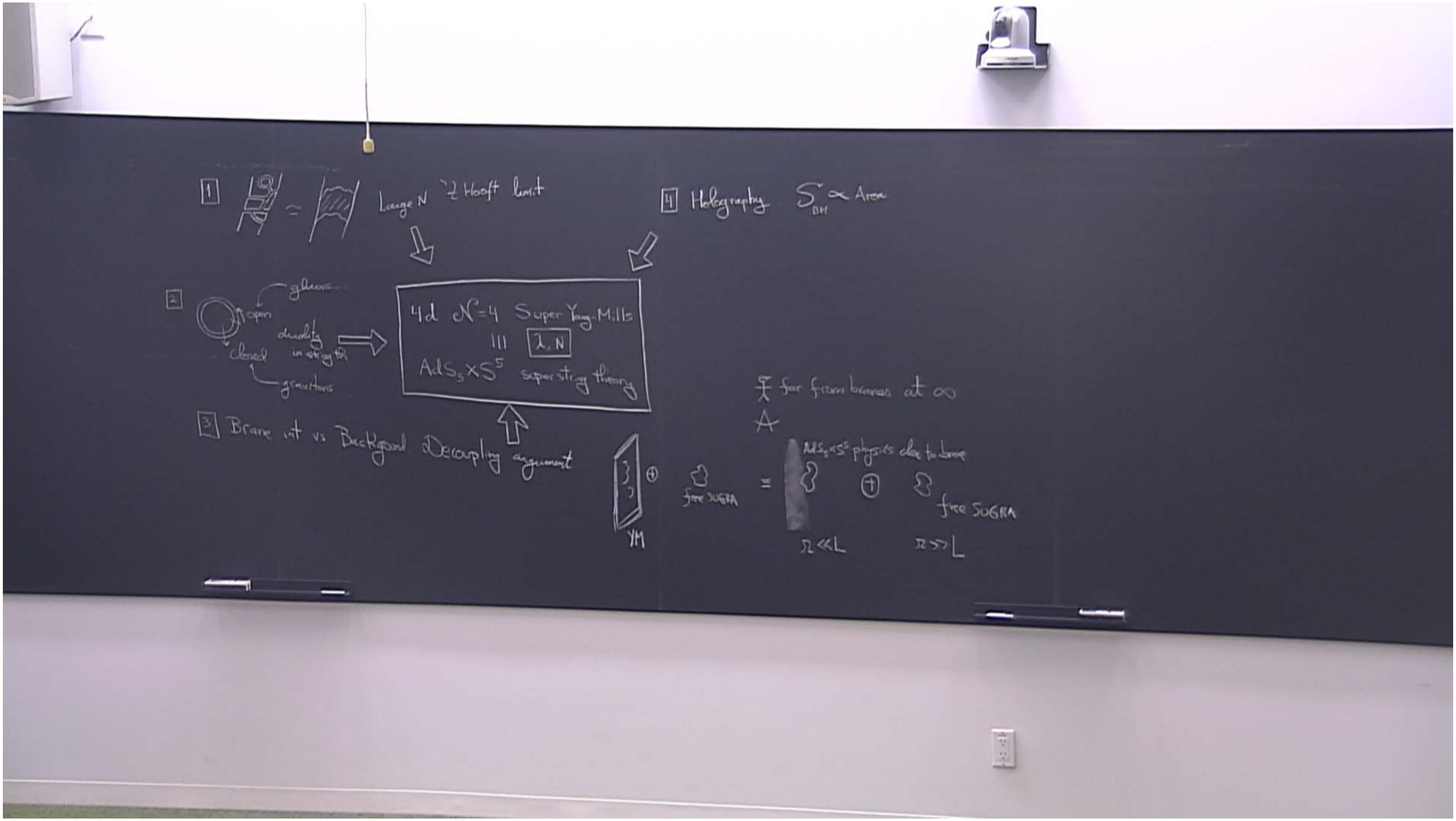
Title: PSI 2015/2016 Explorations in String Theory - Pedro Vieira - 4

Date: Mar 24, 2016 11:30 AM

URL: http://pirsa.org/16030066

Abstract:


Large N 't Hooft limit
Holography S_BH ∝ Area
gluons
open
closed
duality in string th
gravitons
4d N=4 Super Yang-Mills
λ, N
AdS5×S5 superstring theory
Brane int vs Background Decoupling argument
far from branes at ∞
AdS5×S5 physics close to brane
free SUGRA
YM
free SUGRA



1 Large N 't Hooft limit
4 Holography S_BH ∝ Area
2 gluons open closed gravitons duality in string th
4d N=4 Super Yang-Mills
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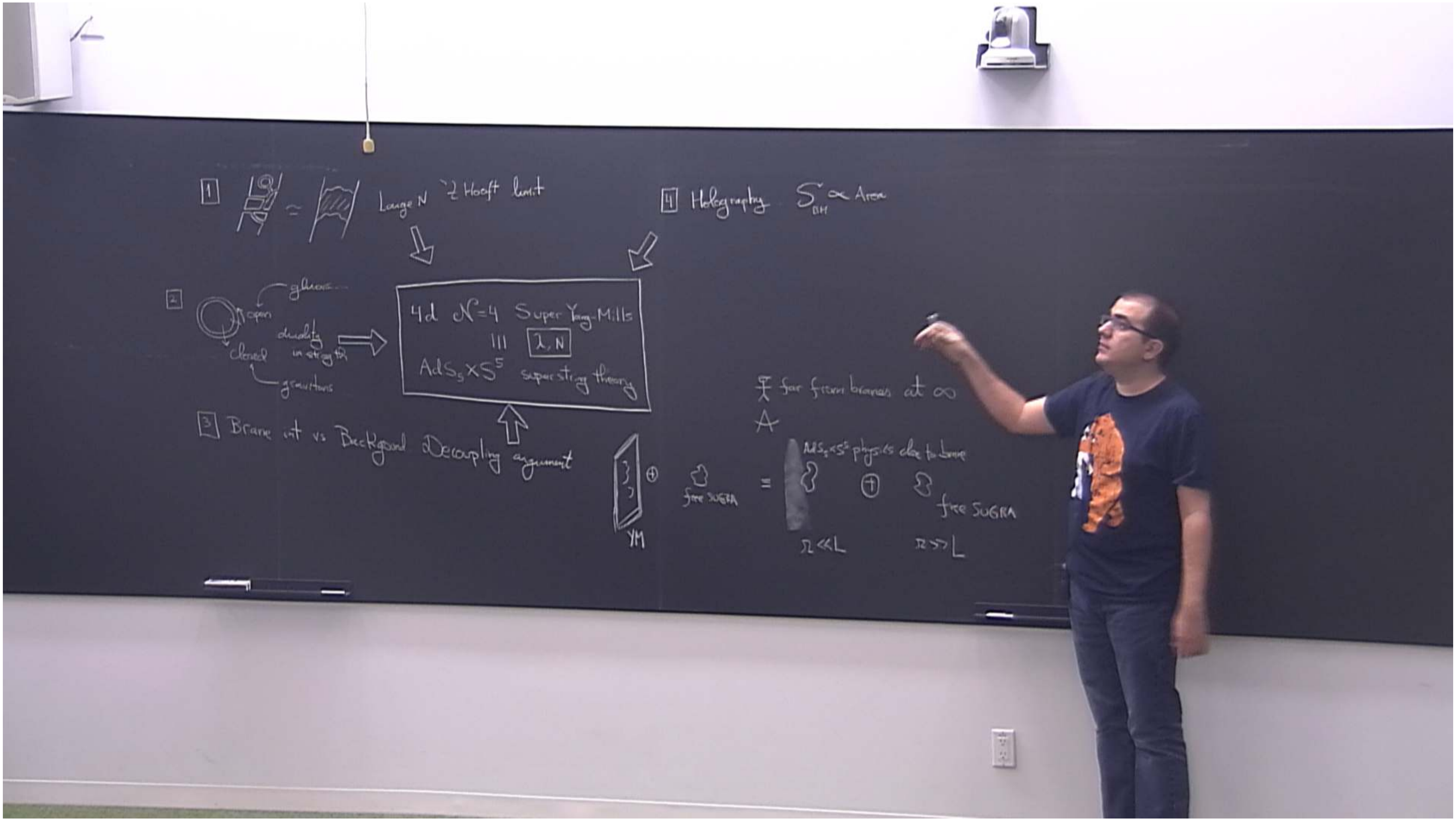

Large N 't Hooft limit
4 Holography S_BH ∝ Area
gluons
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4d N=4 Super Yang-Mills
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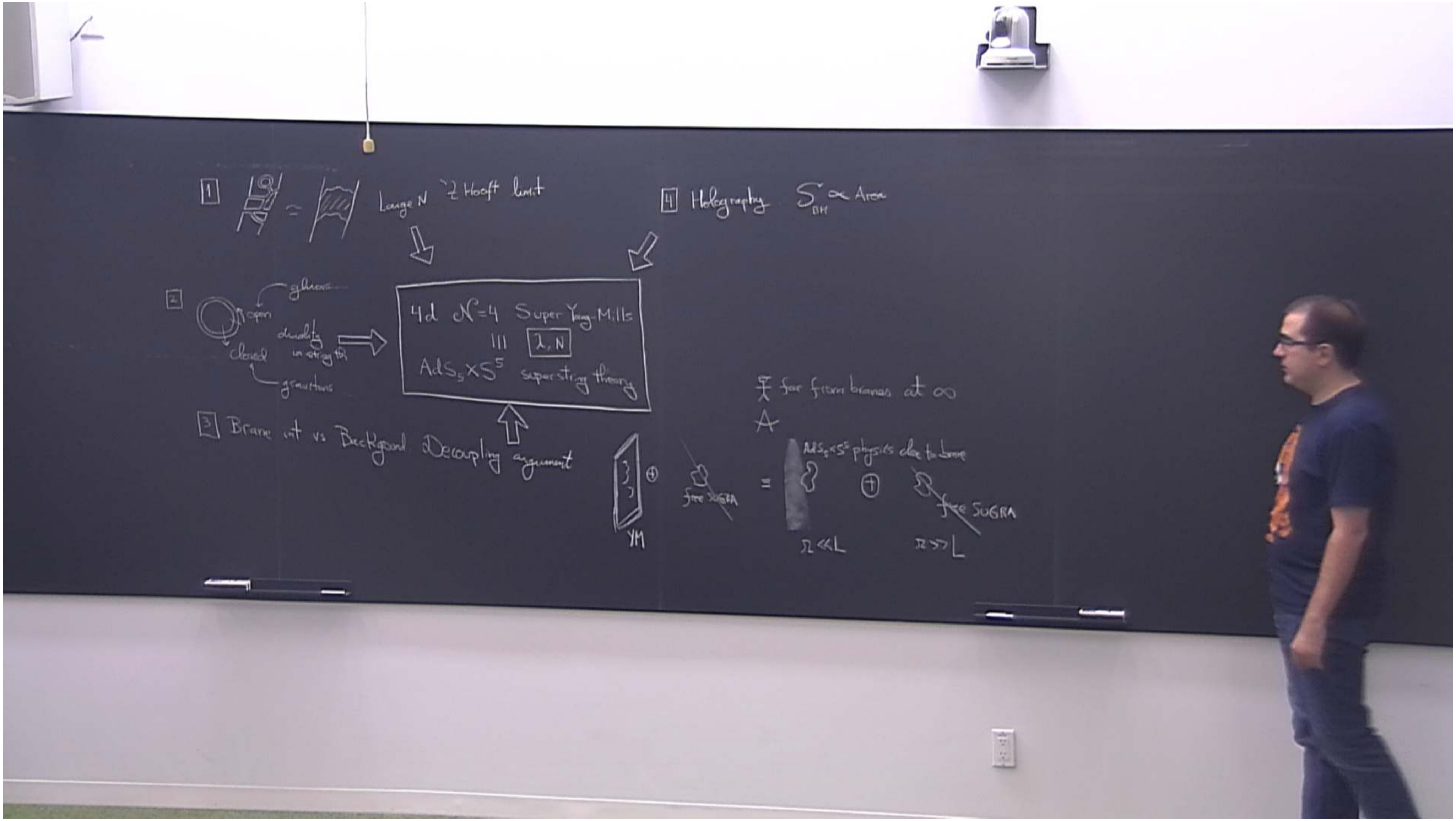
1
Large N 't Hooft limit
4 Holography $S_{BH} \propto$ Area
2
gluons
open
closed
duality in string th
gravitons
4d $\mathcal{N}=4$ Super Yang-Mills
λ, N
$AdS_5 \times S^5$ superstring theory
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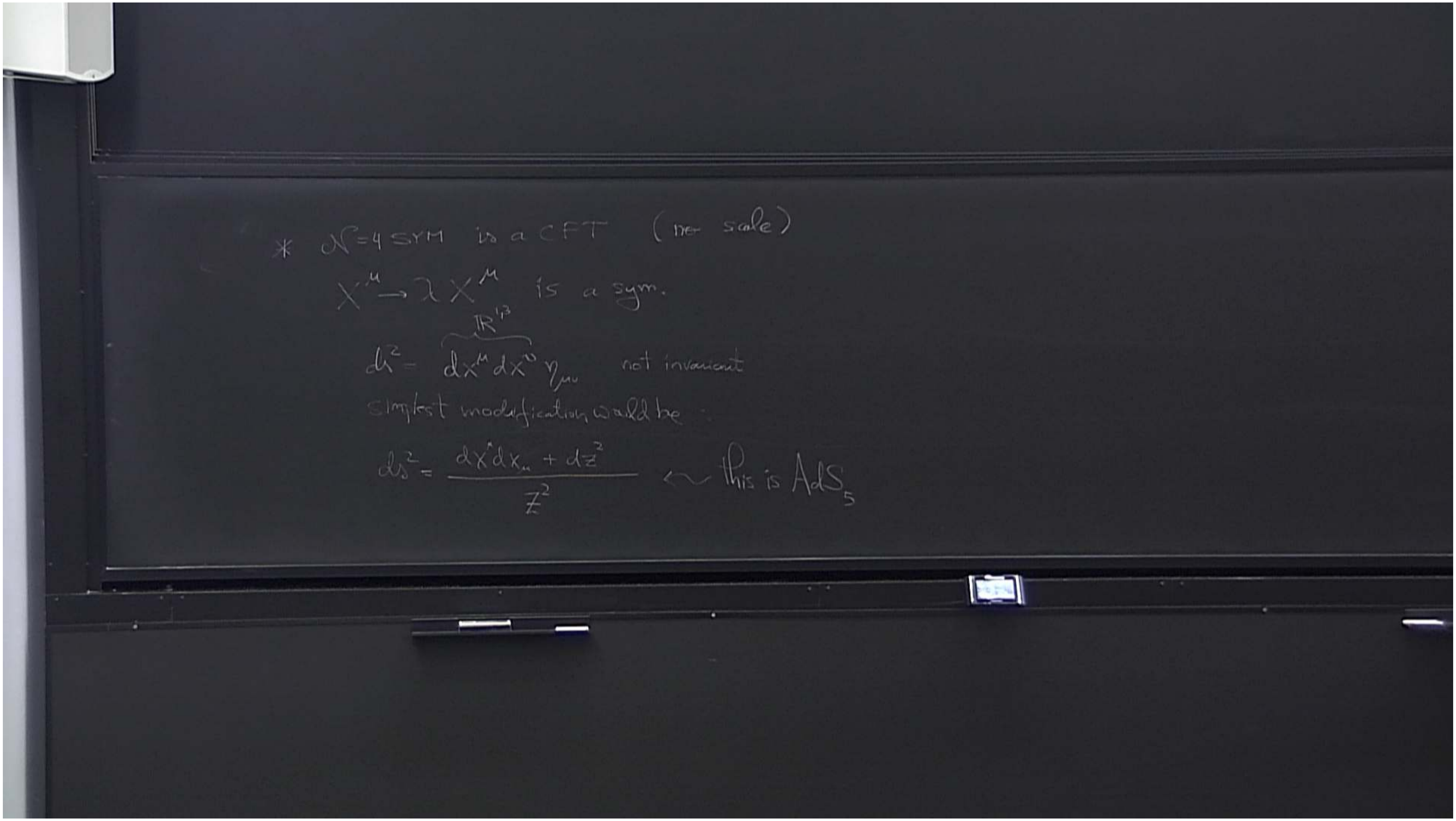
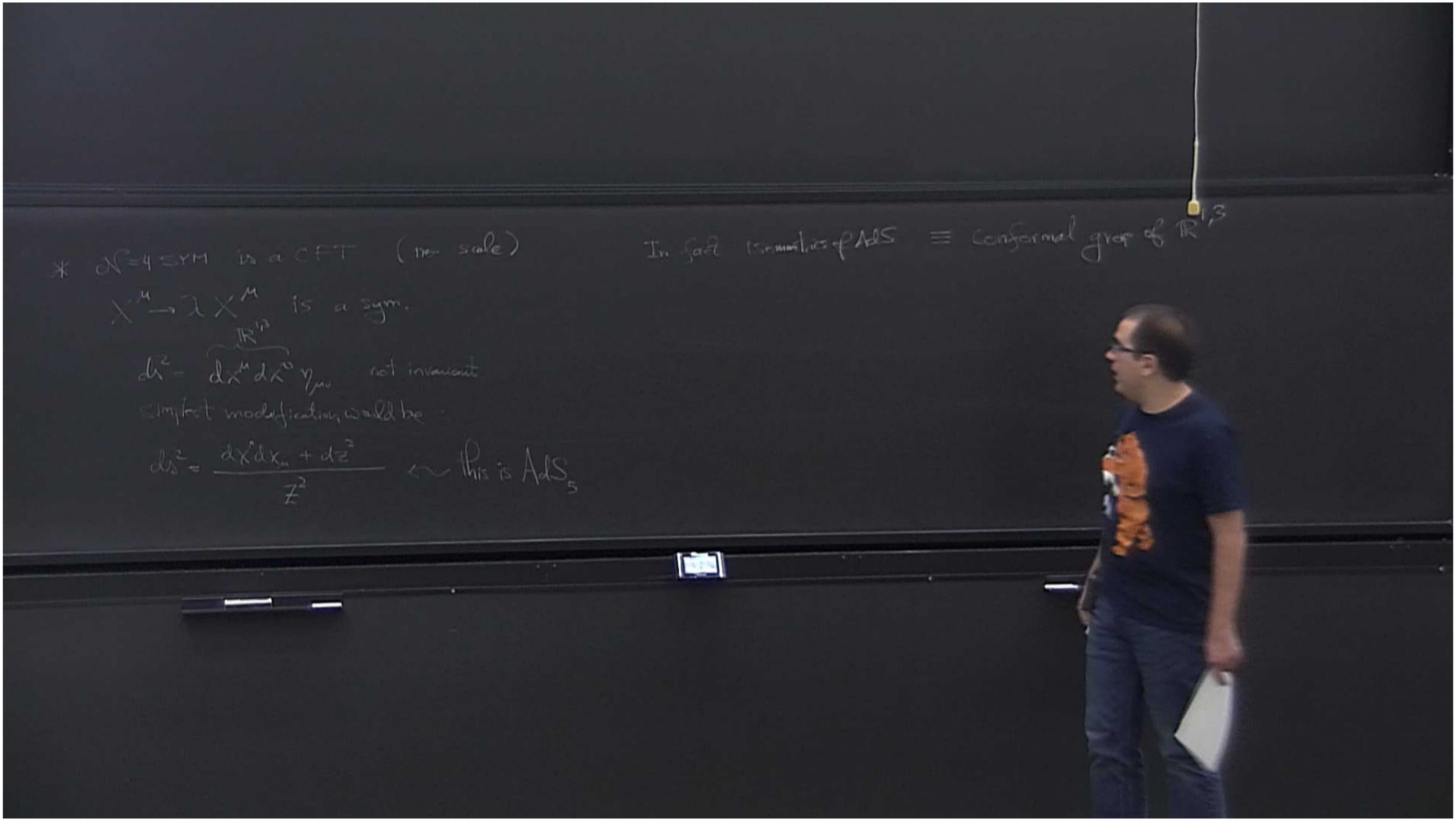
far from branes at ∞
$AdS_5 \times S^5$ physics close to brane
free SUGRA
YM
free SUGRA
r << L
r >> L


* $\mathcal{N}=4$ SYM is a CFT (no scale)
$X^\mu \to \lambda X^\mu$ is a sym.
$ds^2 = \overbrace{dx^\mu dx^\nu}^{\mathbb{R}^{1,3}} \eta_{\mu\nu}$ not invariant
simplest modification would be:
$ds^2 = \frac{dx^\mu dx_\mu + dz^2}{z^2}$ $\leftsquigarrow$ this is AdS_5


* N=4 SYM is a CFT (no scale)
X^μ → λ X^μ is a sym.
R^{1,3}
ds² = dx^μ dx^ν η_μν not invariant
simplest modification would be:
ds² = (dx^μ dx_μ + dz²) / z² ← this is AdS_5
In fact isometries of AdS ≡ conformal group of R^{1,3}

* $\mathcal{N}=4$ SYM is a CFT (no scale)

$X^\mu \to \lambda X^\mu$ is a sym.

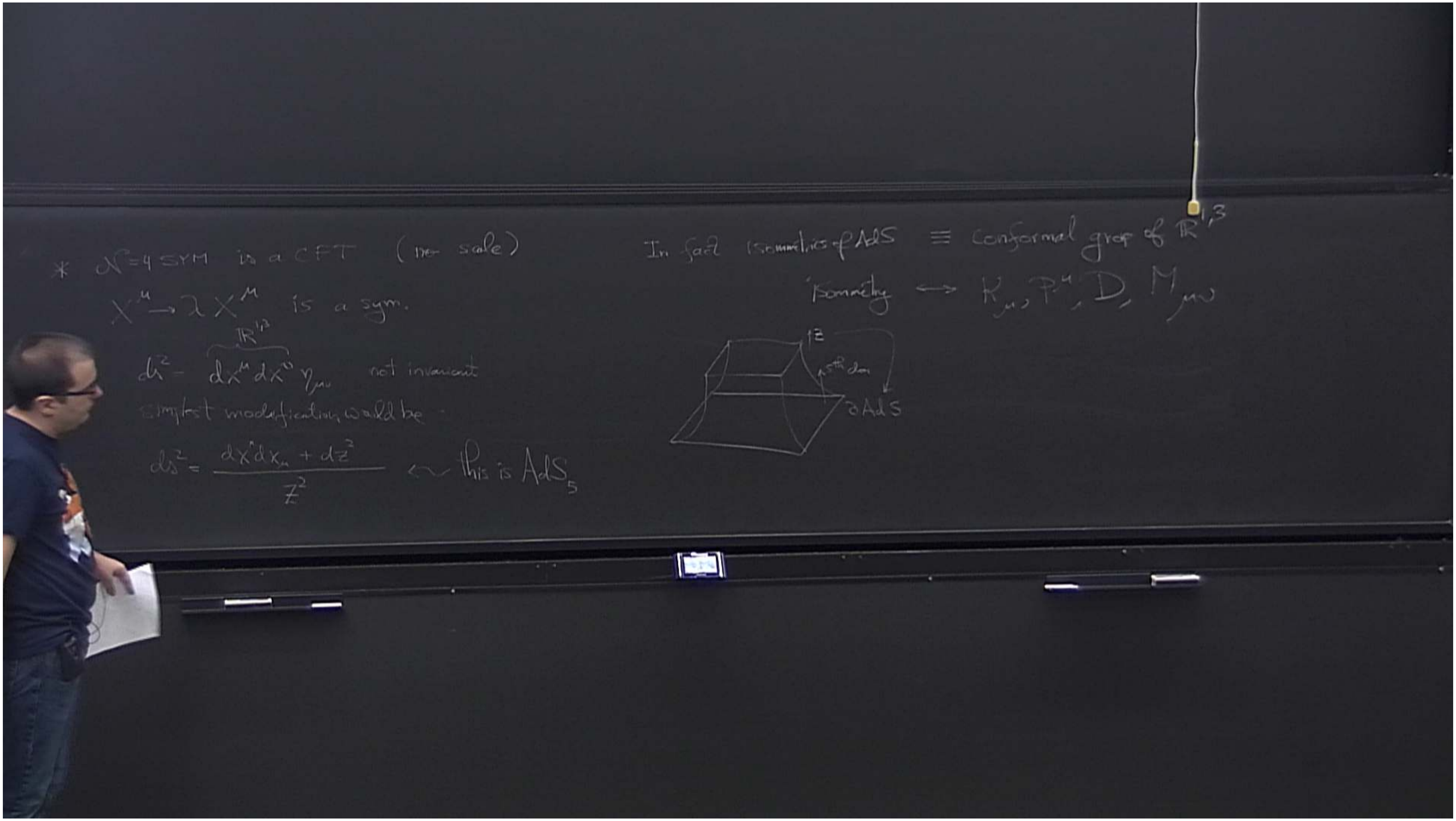
$$ds^2 = \overbrace{dx^\mu dx^\nu \eta_{\mu\nu}}^{\mathbb{R}^{1,3}} \quad \text{not invariant}$$

simplest modification would be :

$$ds^2 = \frac{dx^\mu dx_\mu + dz^2}{z^2} \quad \leftsquigarrow \text{ This is } AdS_5$$

In fact isometries of AdS $\equiv$ conformal group of $\mathbb{R}^{1,3}$

isometry $\longleftrightarrow K_\mu, P^\mu, D, M_{\mu\nu}$


* N=4 SYM is a CFT (no scale)
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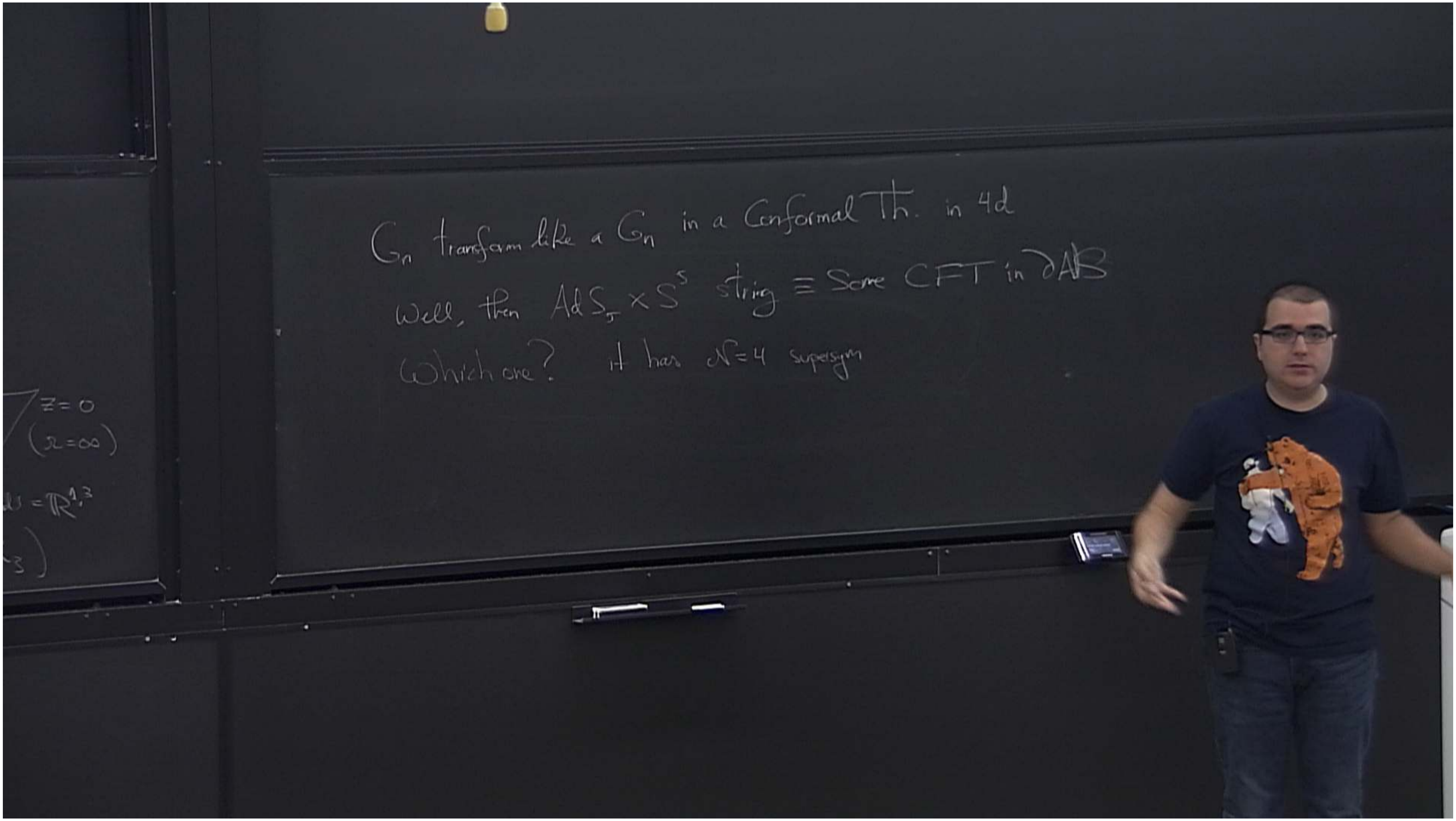
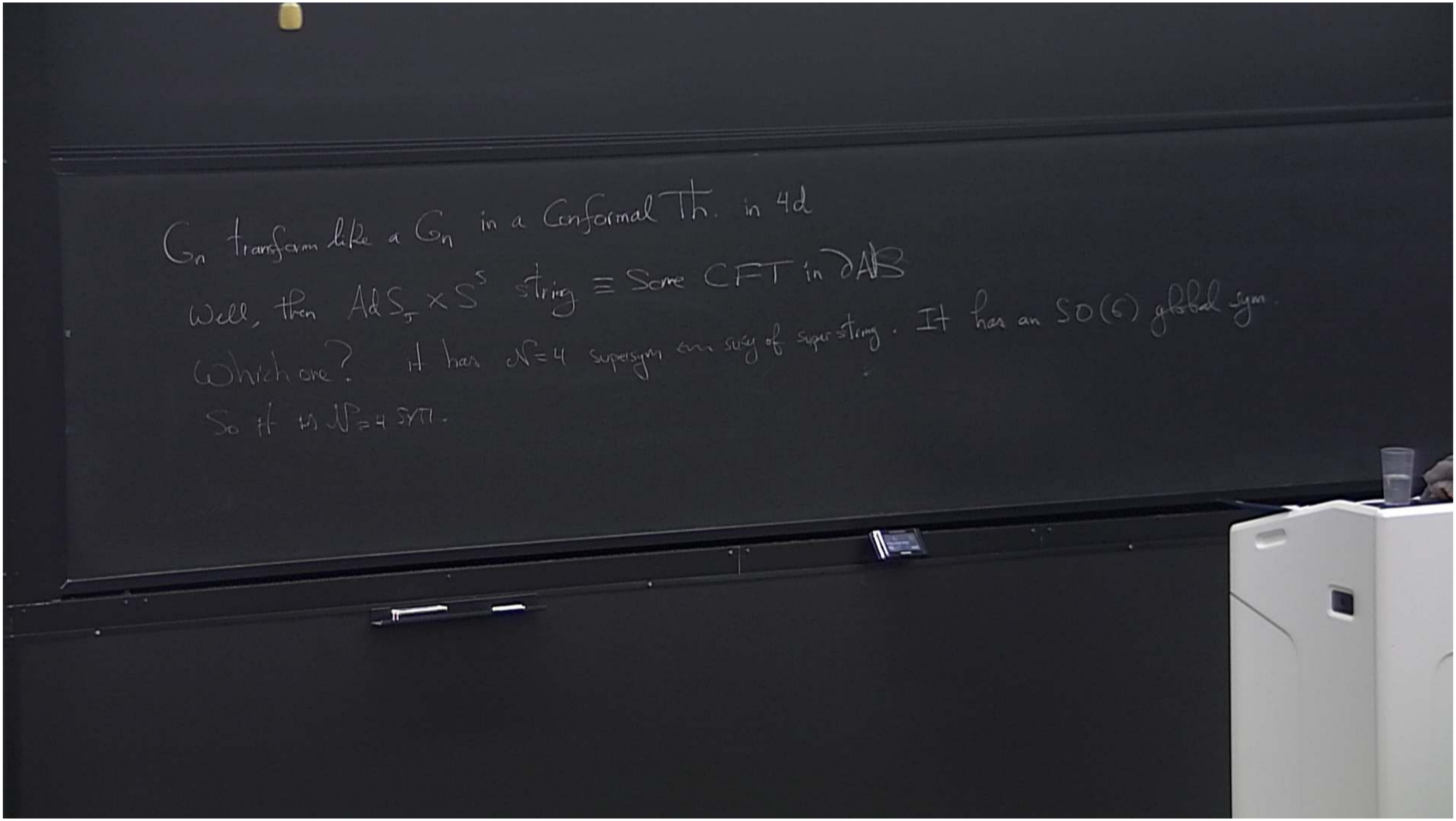
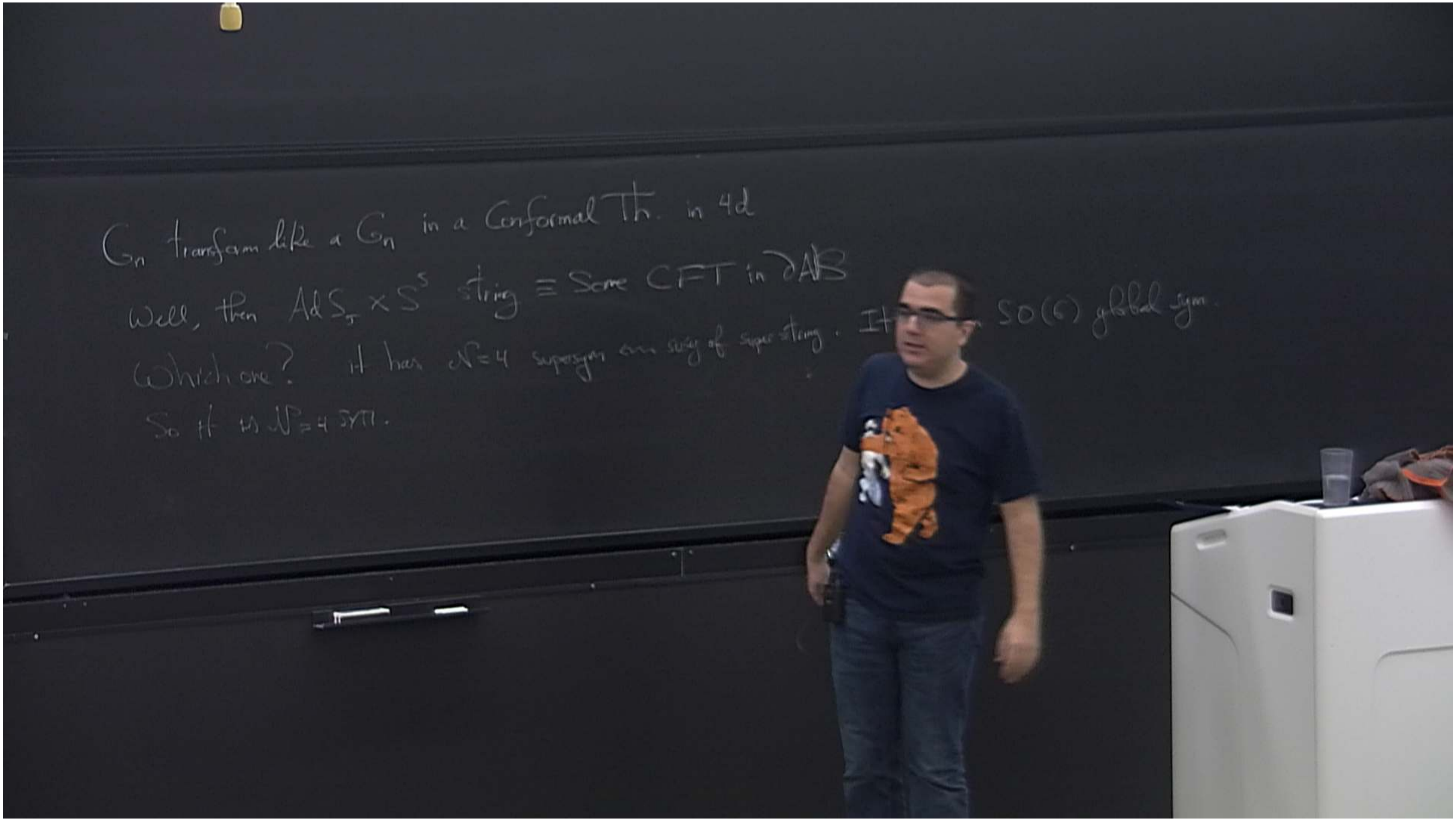
In fact isometries of AdS ≡ conformal group of R^{1,3}
isometry ↔ K_μ, P^μ, D, M_μν
z
5th dim
∂AdS


Gn transform like a Gn in a Conformal Th. in 4d
Well, then AdS5 × S5 string ≡ Some CFT in ∂AdS
Which one? it has N=4 supersym
z = 0
(r = ∞)



Gn transform like a Gn in a Conformal Th. in 4d
Well, then AdS5 × S5 string ≡ Some CFT in ∂AdS
Which one? it has N=4 supersym susy of superstring. It has an SO(6) global sym.
So it is N=4 SYM.



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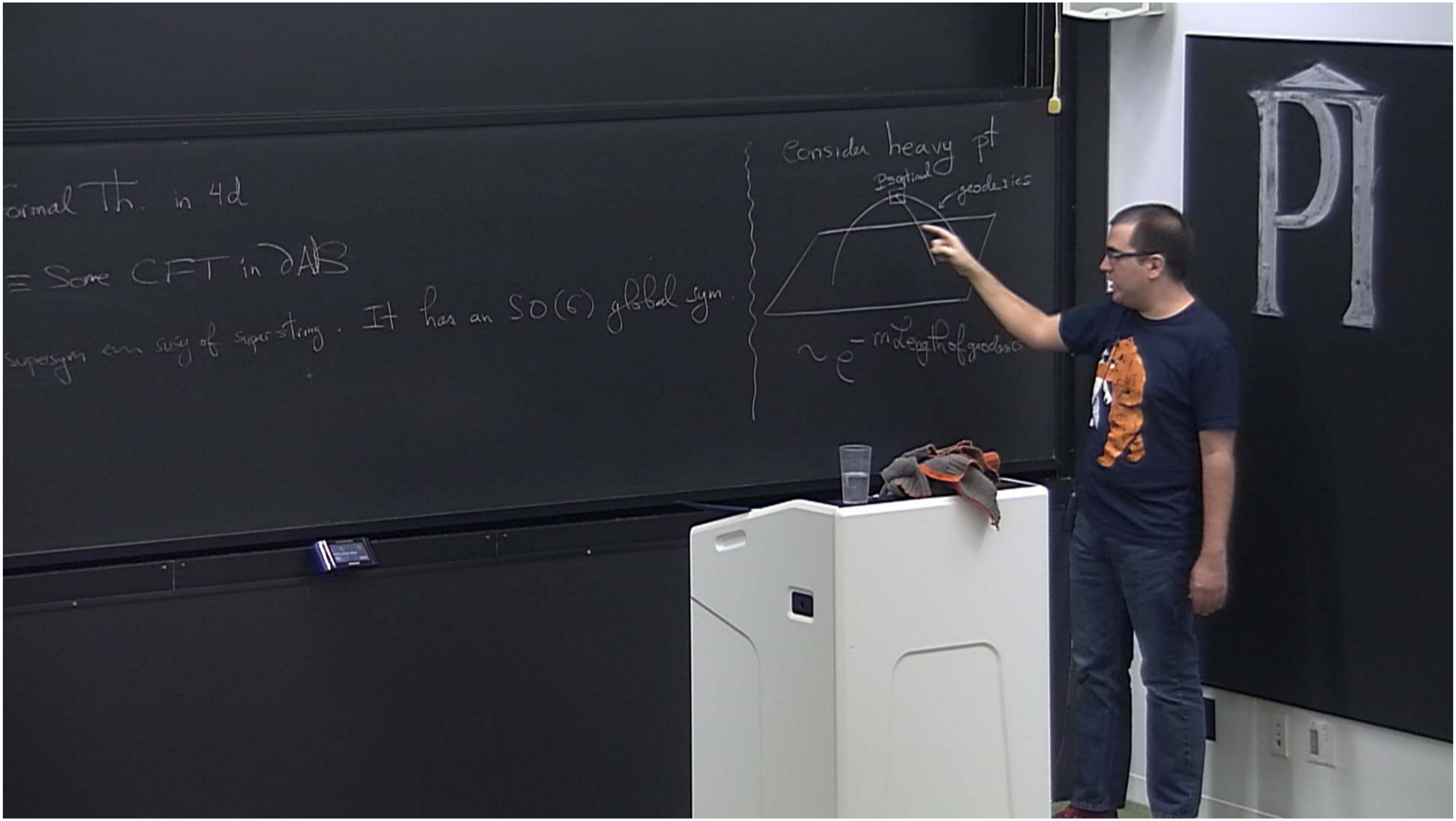
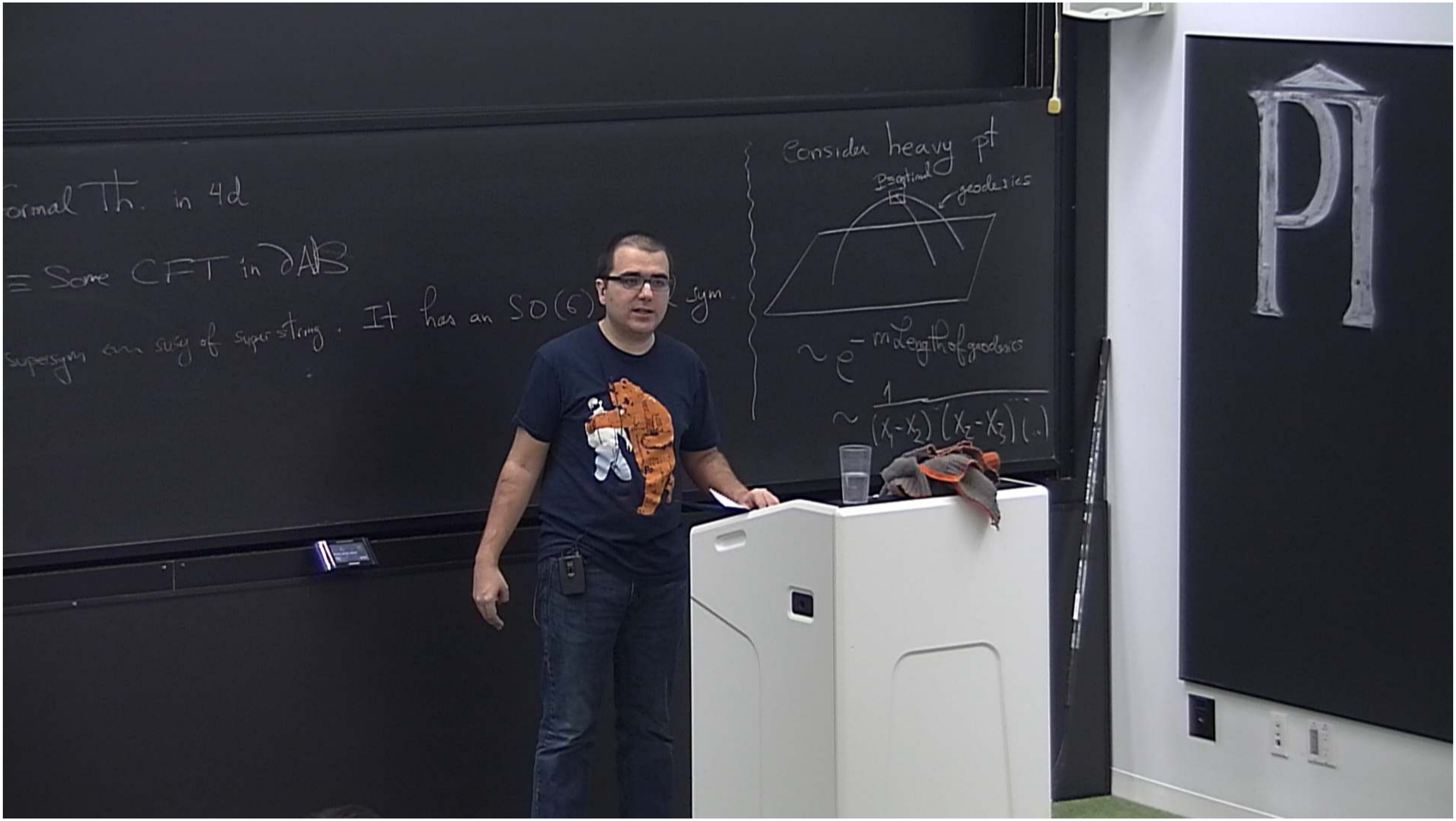
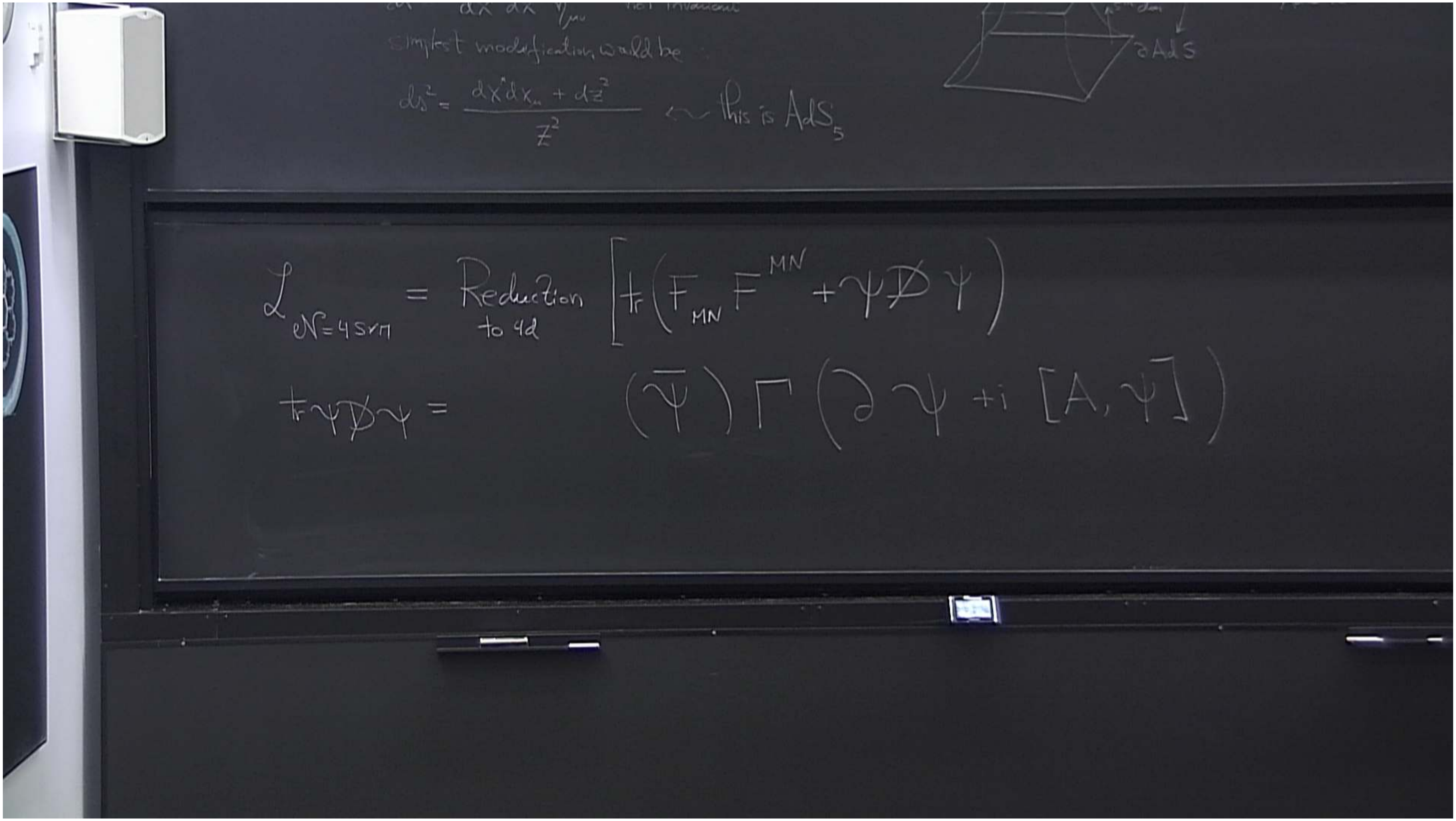
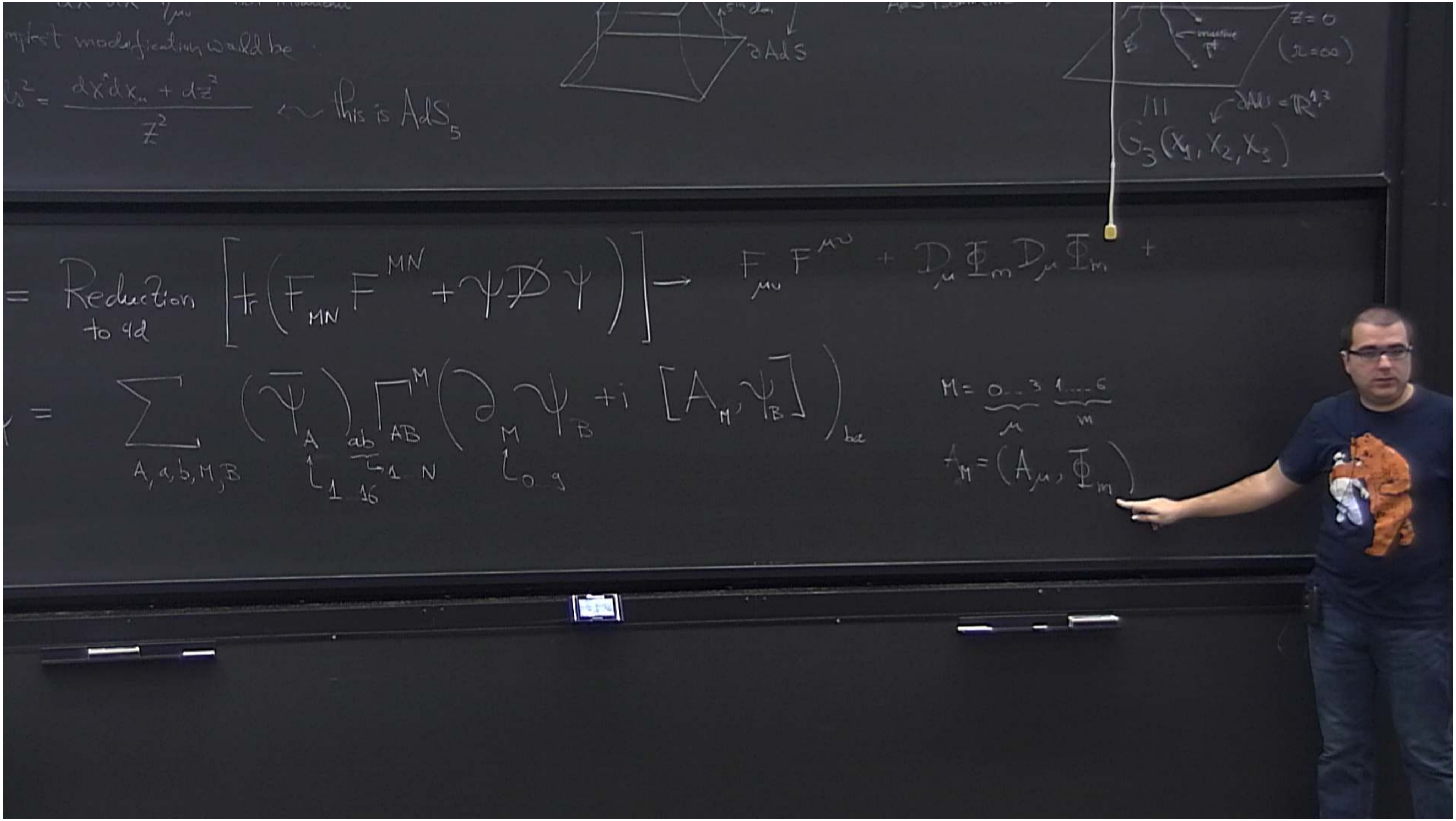
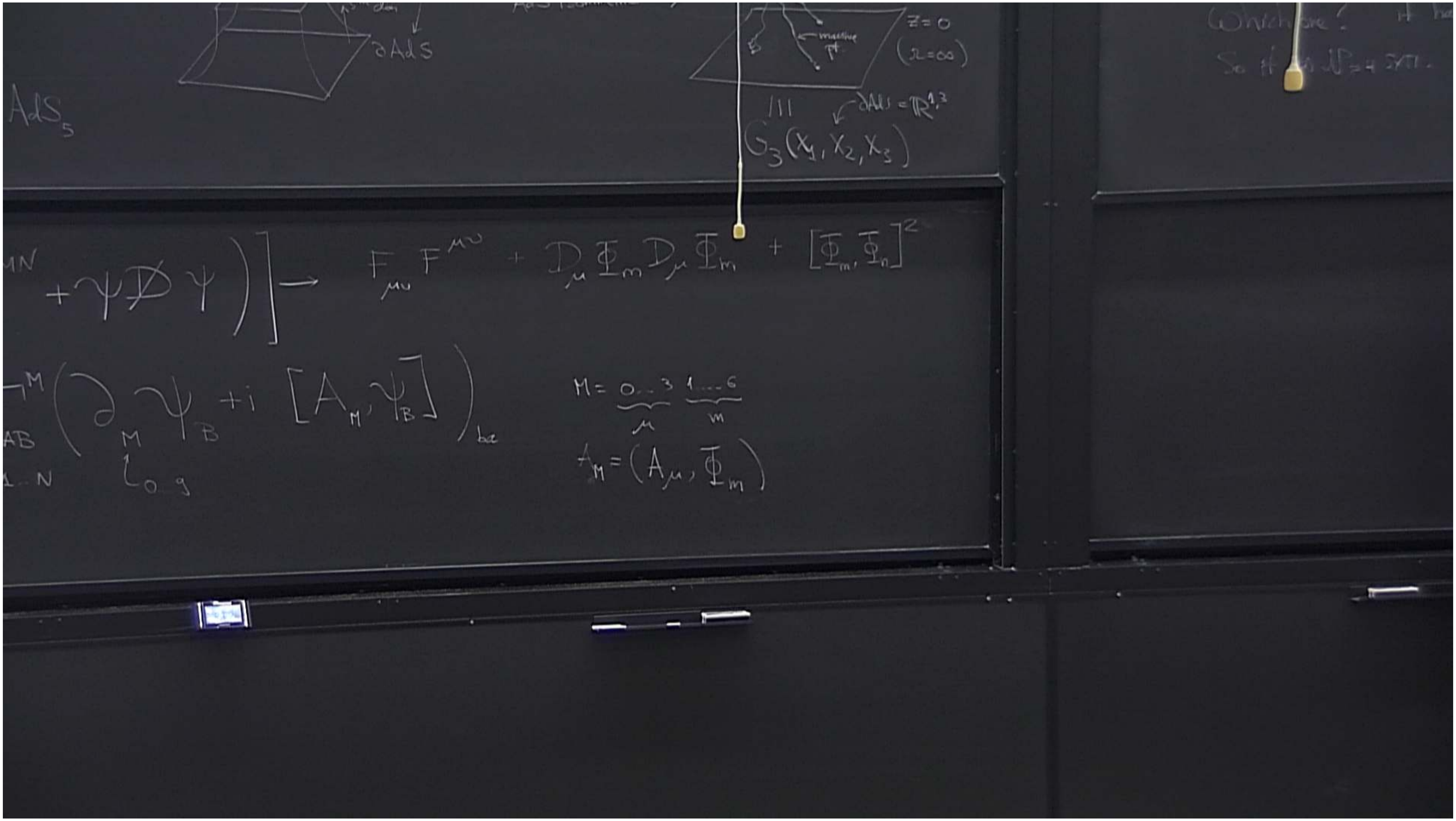
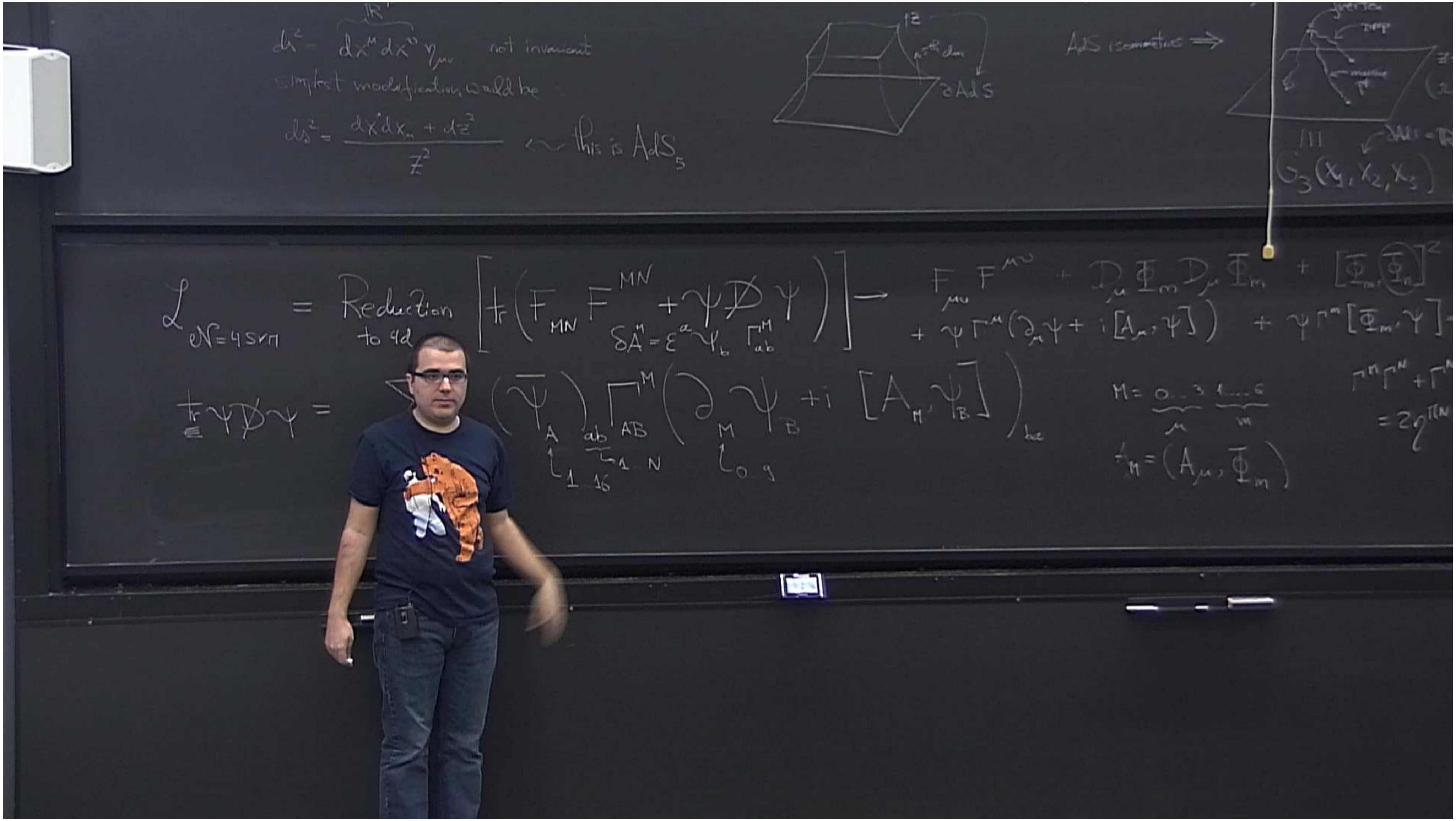

ormal Th. in 4d
= Some CFT in ∂AdS
It has an SO(6) global sym.
Consider heavy pt
geodesics
PI

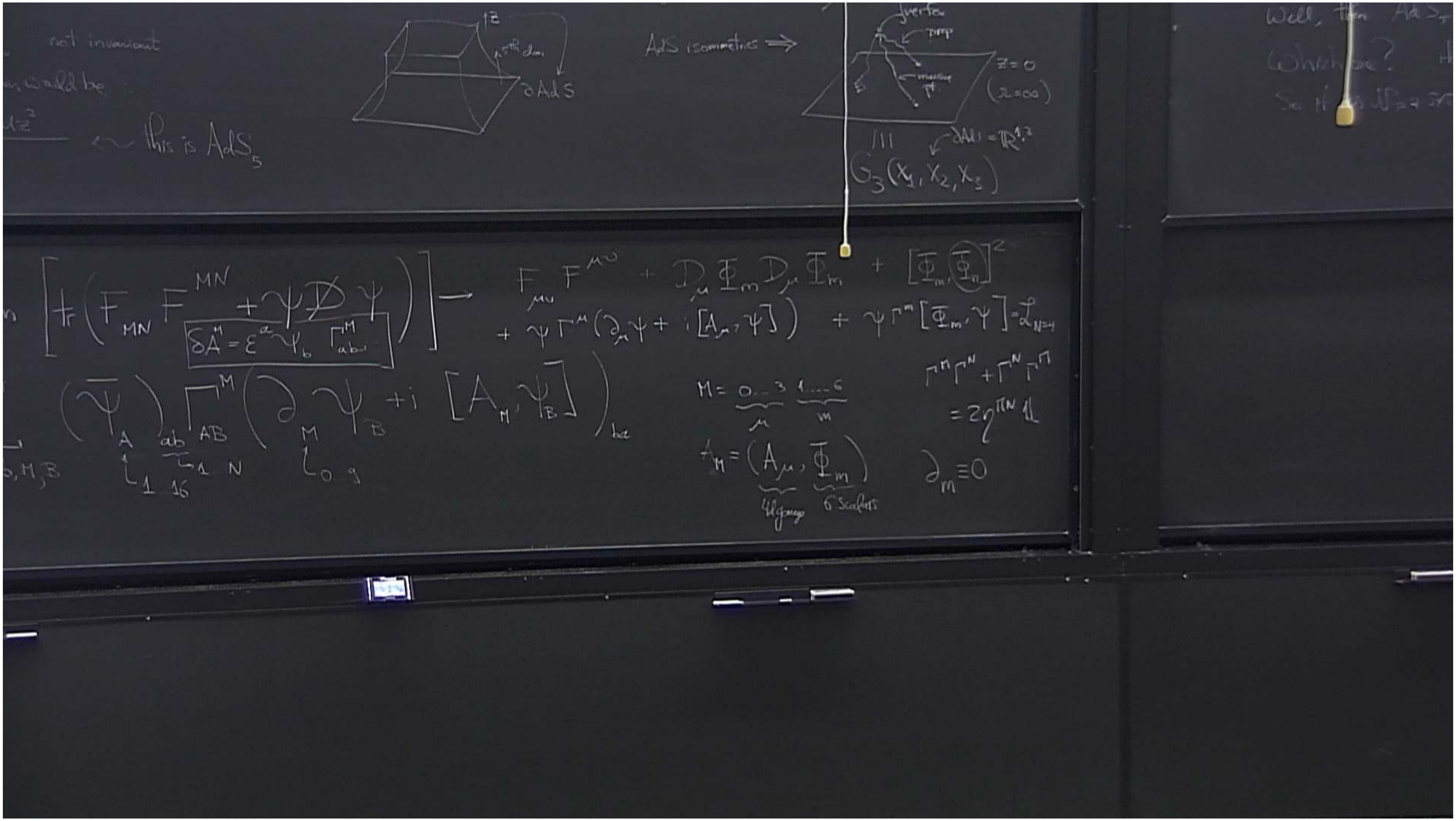

ormal Th. in 4d
≡ Some CFT in ∂AdS
It has an SO(6)
sym.
supersym
susy of superstring
Consider heavy pt
geodesics
~ e^{- m Length of geodesics}
~ 1/((x1-x2)(x2-x3)(..))
PI

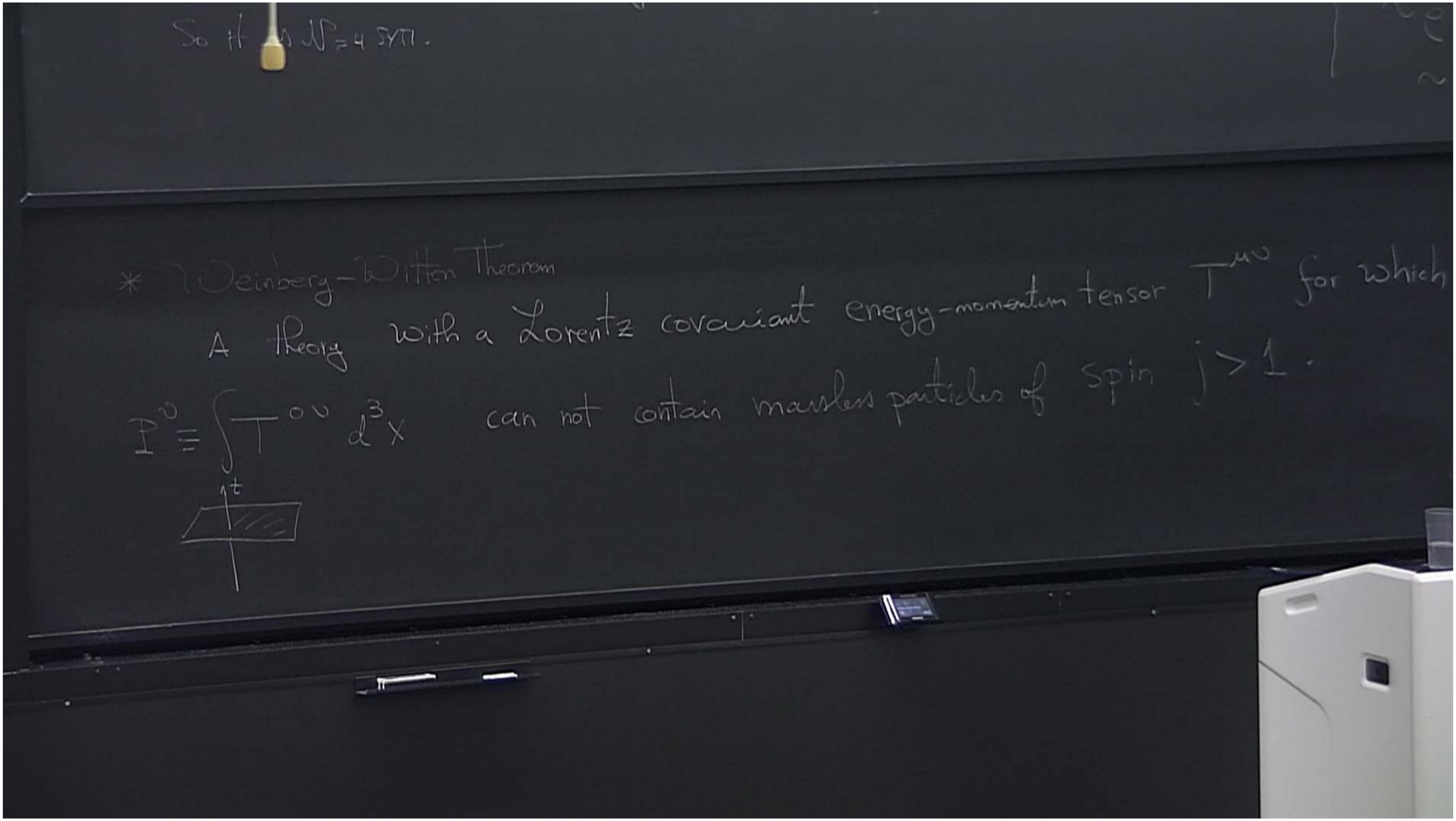

simplest modification would be
ds² = dx^μ dx_μ + dz² / z² ⟵ this is AdS5
∂AdS
L N=4 SYM = Reduction to 4d [tr(F_MN F^MN + ψ D ψ)
tr ψ D ψ = (Ψ̄) Γ (∂ψ +i [A, ψ])


simplest modification would be
$ds^2 = \frac{dx^\mu dx_\mu + dz^2}{z^2}$ this is AdS_5
∂AdS
$z = 0$ $(r = \infty)$
$\partial AdS = \mathbb{R}^{1,3}$
$G_3(x_1, x_2, x_3)$
$=$ Reduction to 4d $\left[tr \left(F_{MN} F^{MN} + \psi \not{D} \psi \right) \right] \to F_{\mu\nu} F^{\mu\nu} + D_\mu \Phi_m D_\mu \Phi_m +$
$= \sum_{A,a,b,M,B} (\bar{\Psi}_A)_{ab} \Gamma^M_{AB} \left(\partial_M \Psi_B + i [A_M, \Psi_B] \right)_{ba}$
$1 \ldots 16$ $1 \ldots N$ $0 \ldots 9$
$M = \underbrace{0 \ldots 3}_{\mu} \underbrace{1 \ldots 6}_{m}$
$A_M = (A_\mu, \Phi_m)$


∂AdS
AdS5
z = 0
(r = ∞)
massive
∂AdS = ℝ^{1,3}
G3(x1, x2, x3)
Which one?
+ ψ D̸ ψ)] → F_{μν} F^{μν} + D_μ Φ_m D_μ Φ_m + [Φ_m, Φ_n]^2
(∂_M ψ_B + i [A_M, ψ_B])_{ba}
M = 0...3 1...6
μ m
A_M = (A_μ, Φ_m)


not invariant
simplest modification would be
this is AdS5
∂AdS
AdS isometries
Reduction to 4d


not invariant
this is AdS5
∂AdS
AdS isometries ⟹
z = 0
(r = ∞)
∂AdS = R^{1,3}
G3(x1, x2, x3)
M = 0...3 1...6
6 scalars

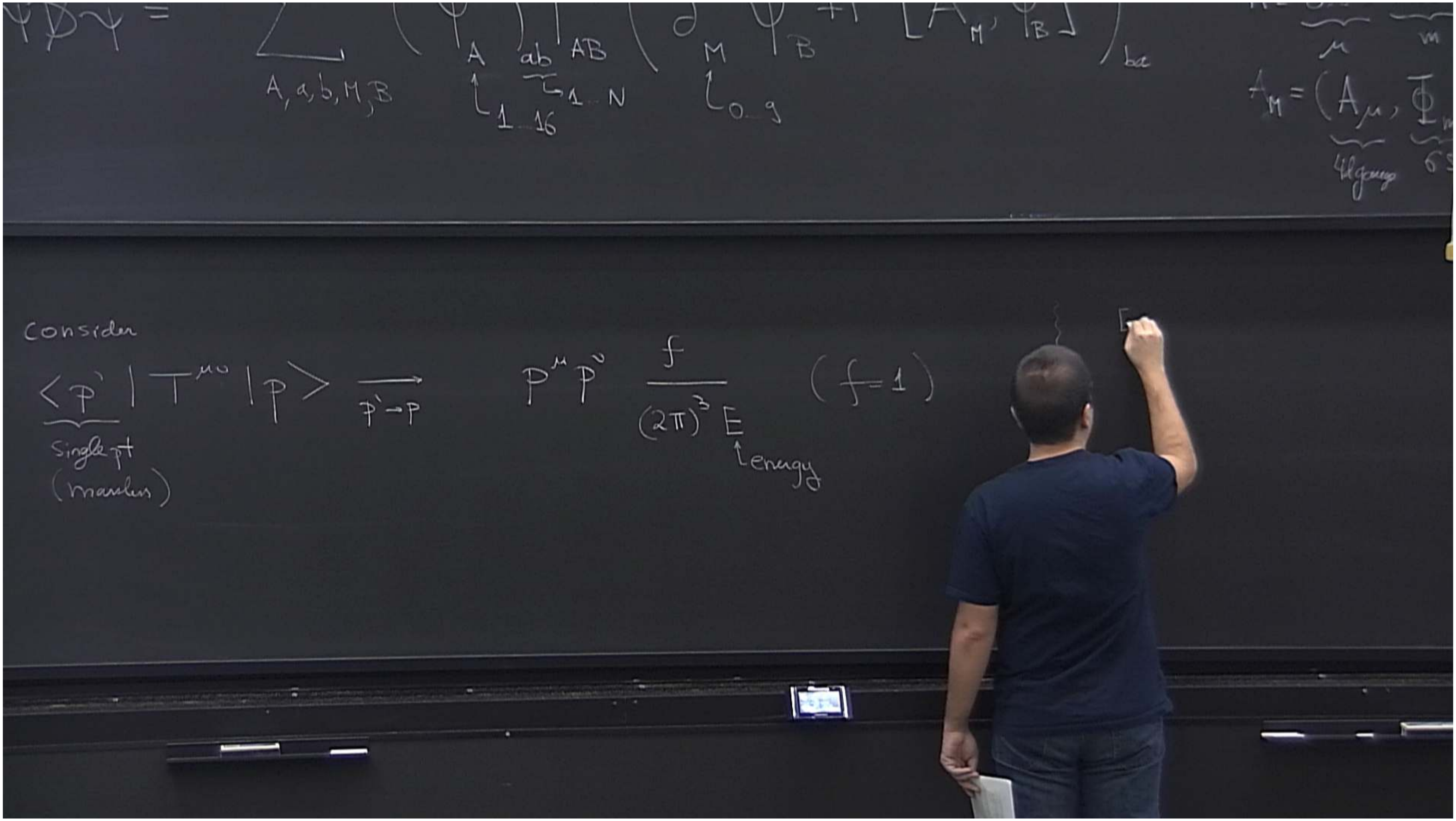


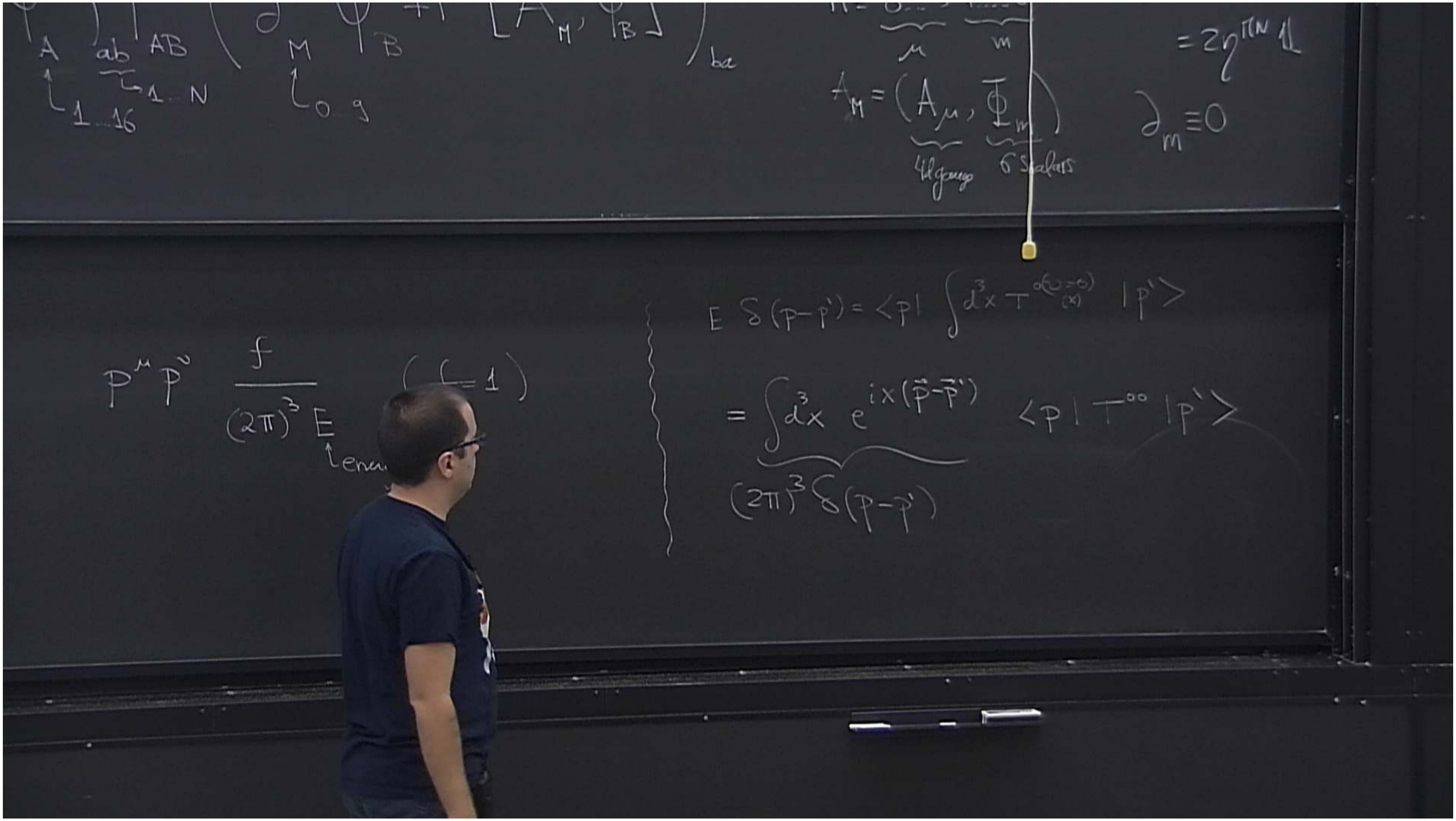
So it is N=4 SYM.
* Weinberg-Witten Theorem
A theory with a Lorentz covariant energy-momentum tensor T^μν for which
P^ν = ∫T^0ν d^3x can not contain massless particles of spin j > 1.
t

A, a, b, M, B — A: $1 \ldots 16$; ab: $1 \ldots N$; M: $0 \ldots 9$

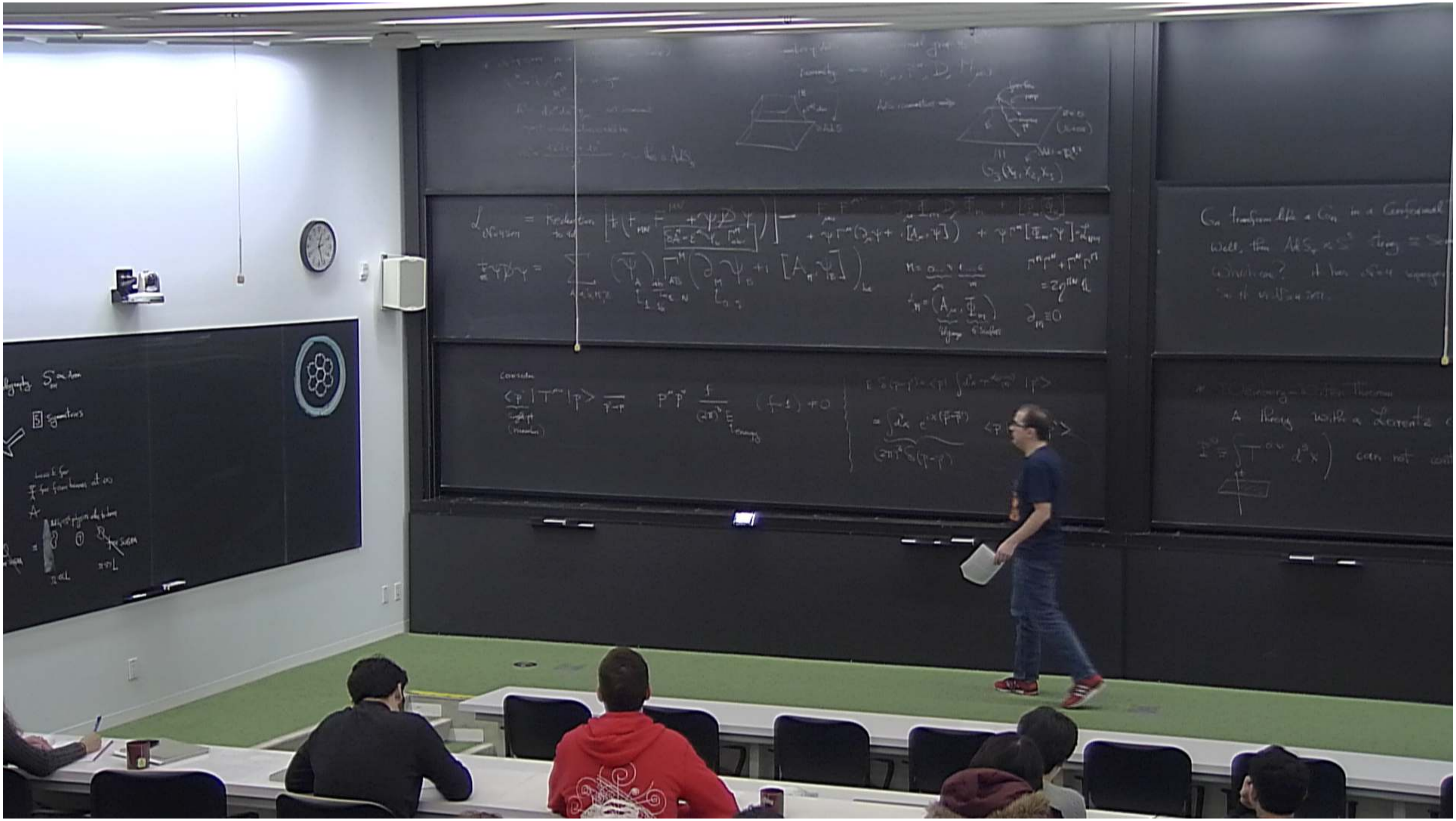
Consider

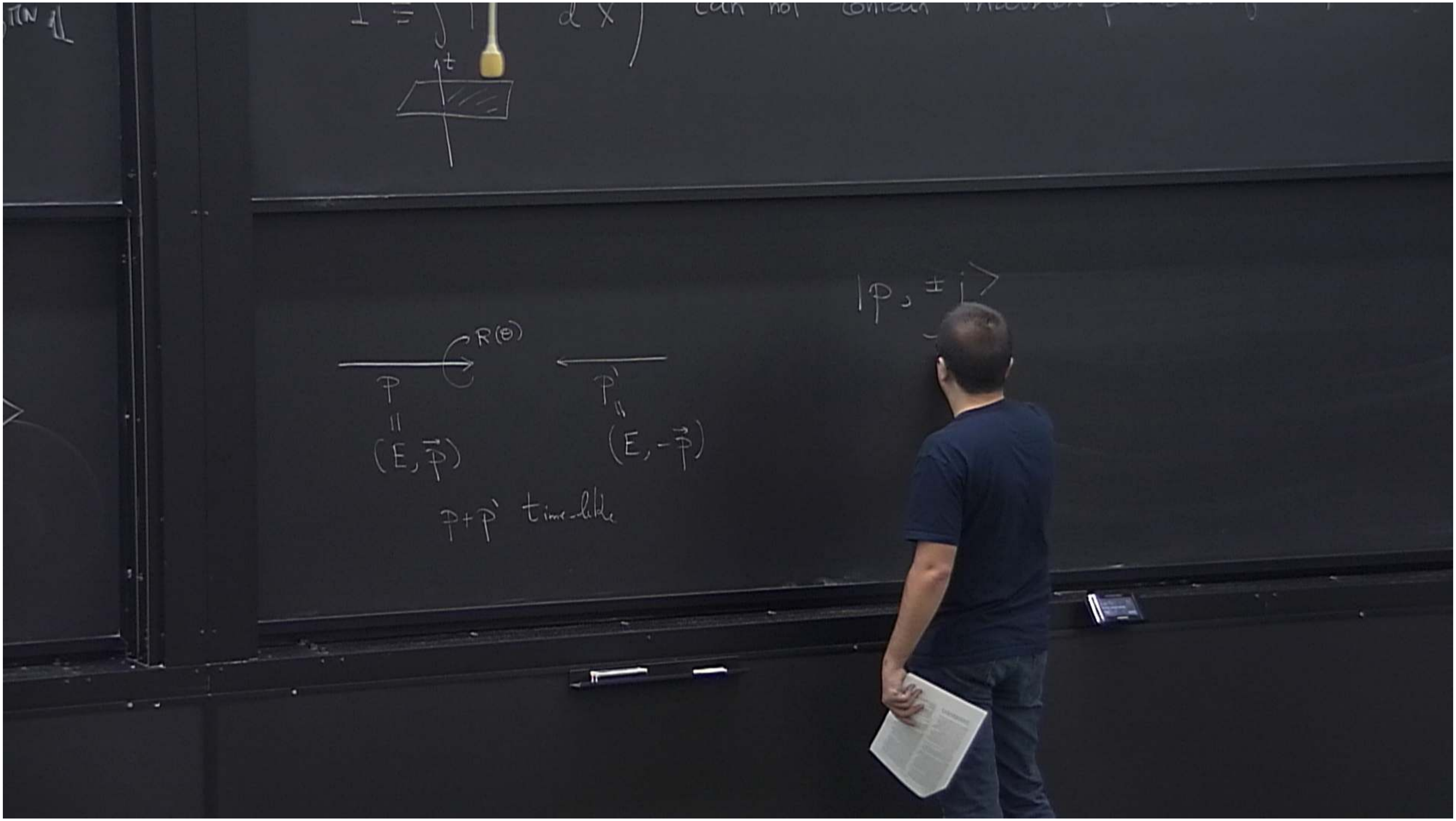
$$\underbrace{\langle p'}_{\text{single pt}} | T^{\mu\nu} | p \rangle \xrightarrow[p' \to p]{} p^\mu p^\nu \frac{f}{(2\pi)^3 \underset{\uparrow \text{energy}}{E}} \qquad (f = 1)$$

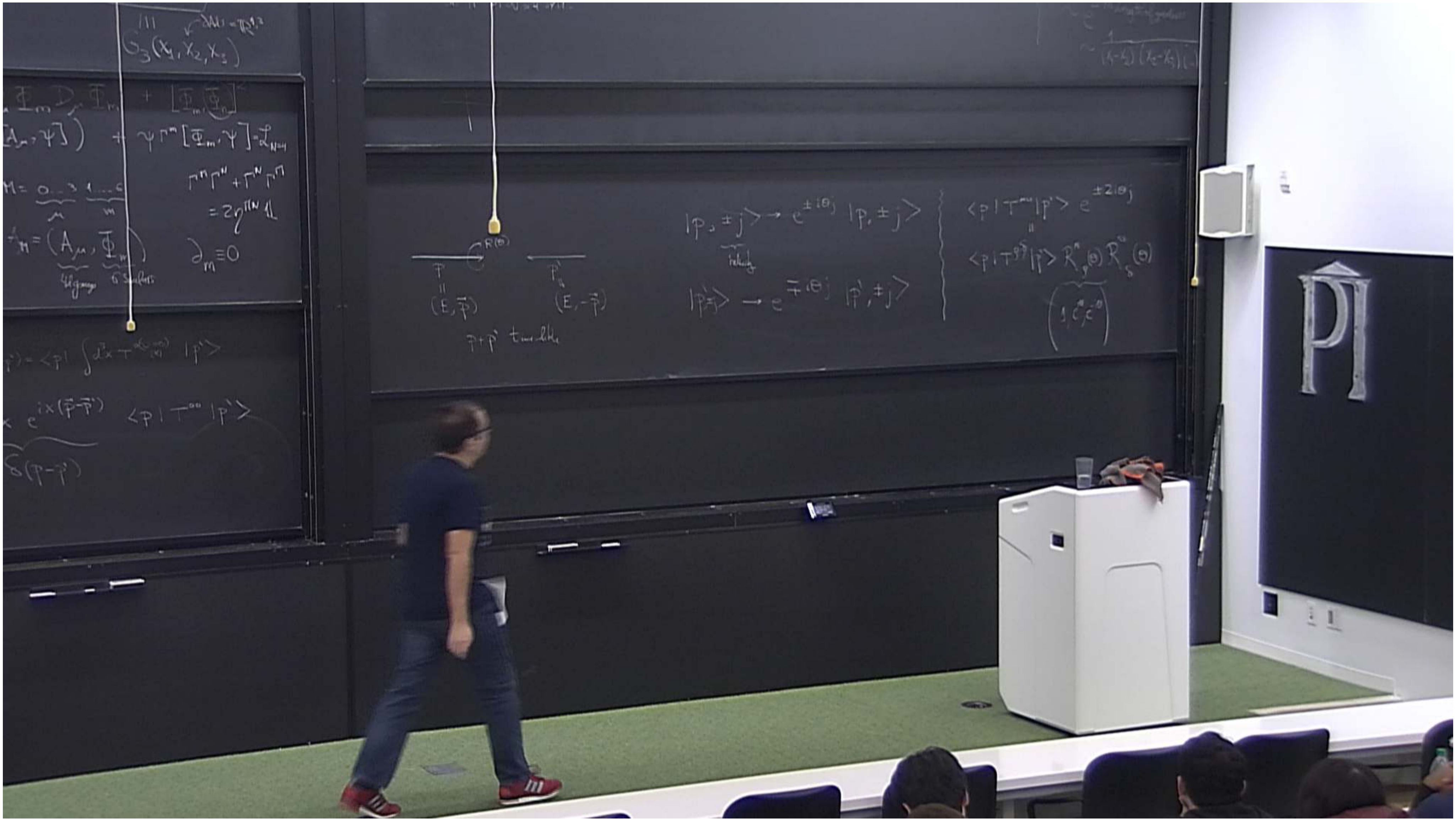

A, a, b, M, B
1 … 16
1 … N
0 … 9
4d gauge
Consider
single pt
(massless)
energy
(f=1)

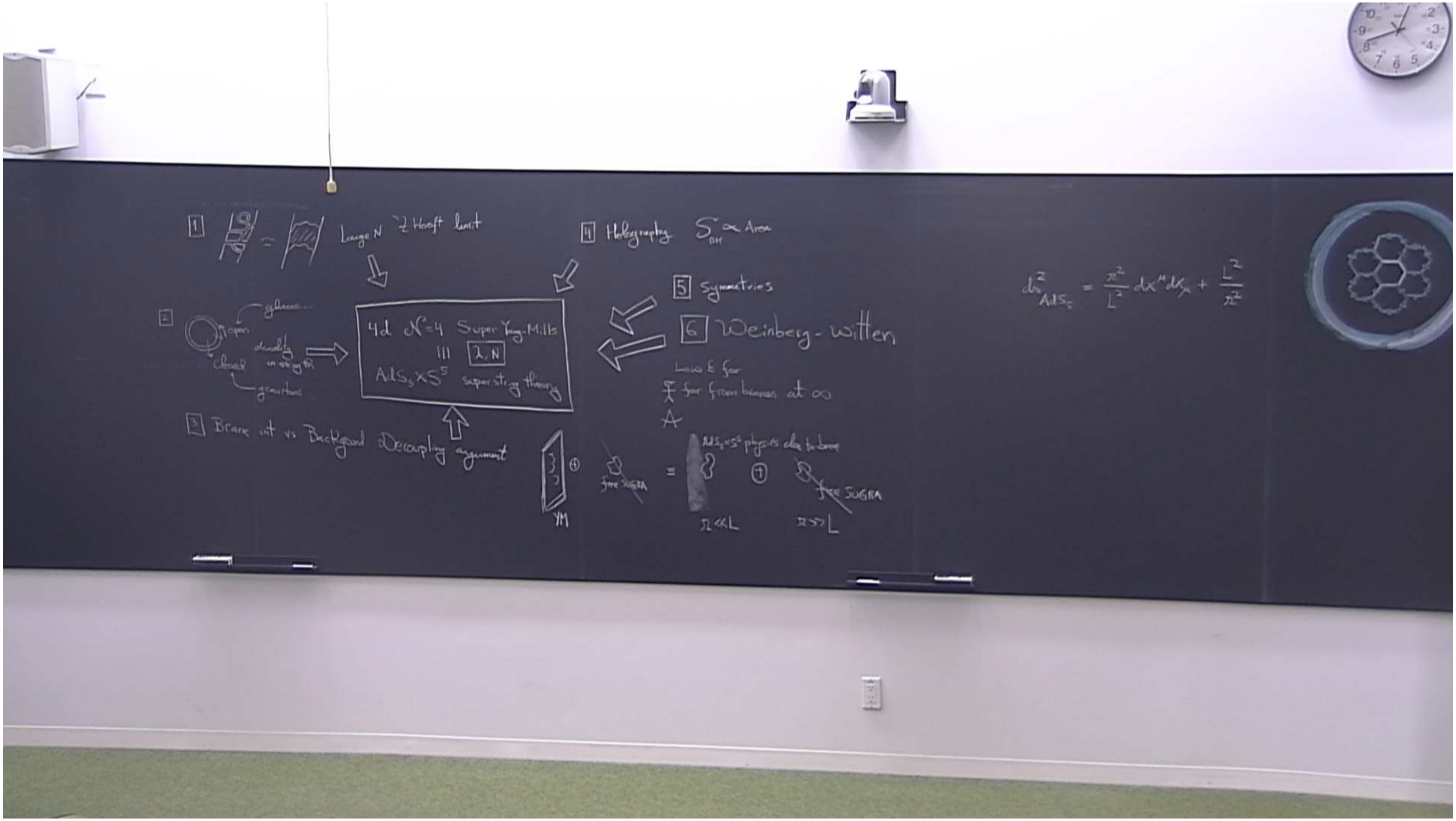


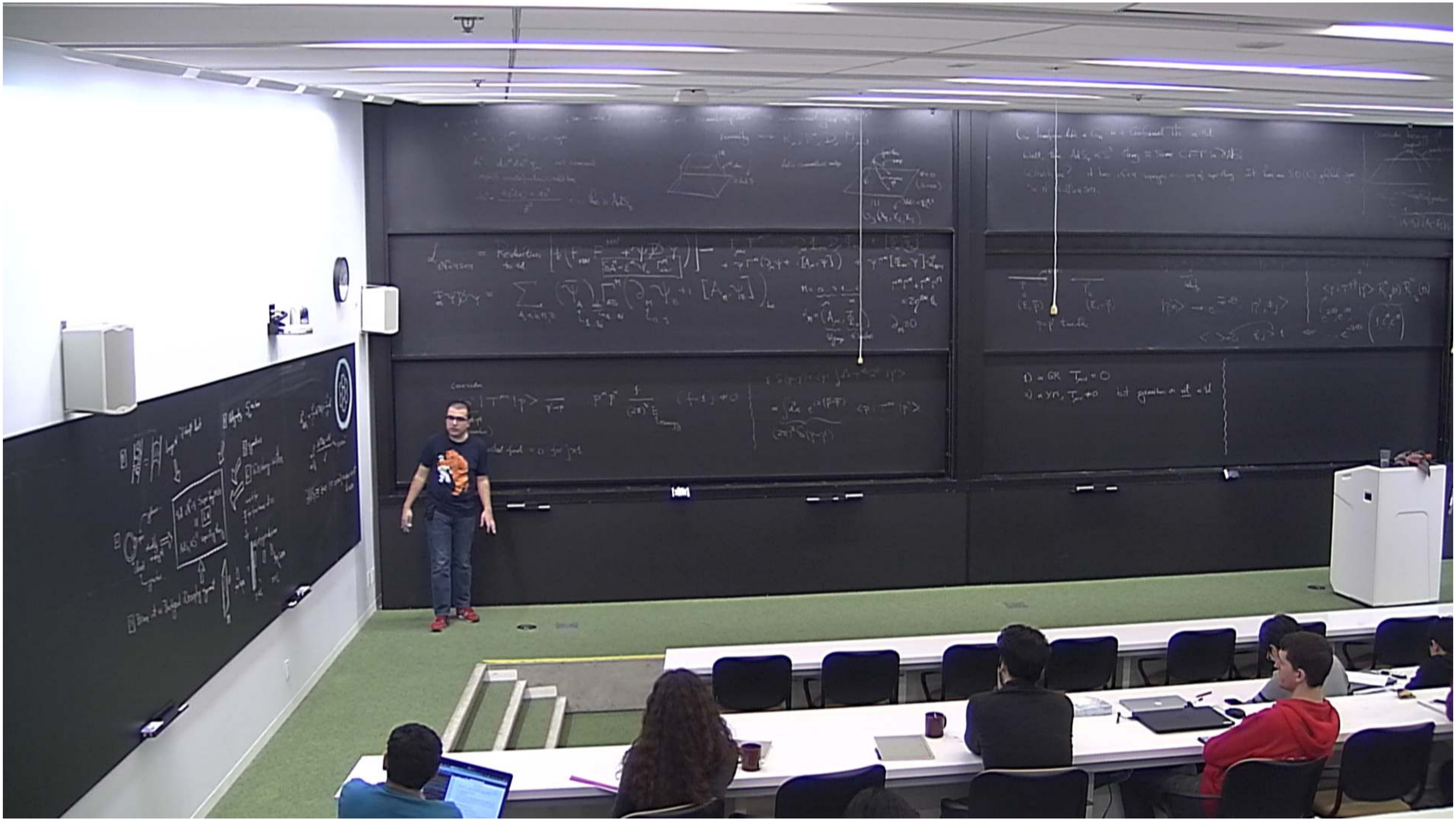
A_M = (A_μ, Φ_m)
4d gauge
6 Scalars
∂_m ≡ 0
E δ(p−p') = <p| ∫d³x T |p'>
= ∫d³x e^{ix(p⃗−p⃗')} <p| T^{00} |p'>
(2π)³ δ(p−p')

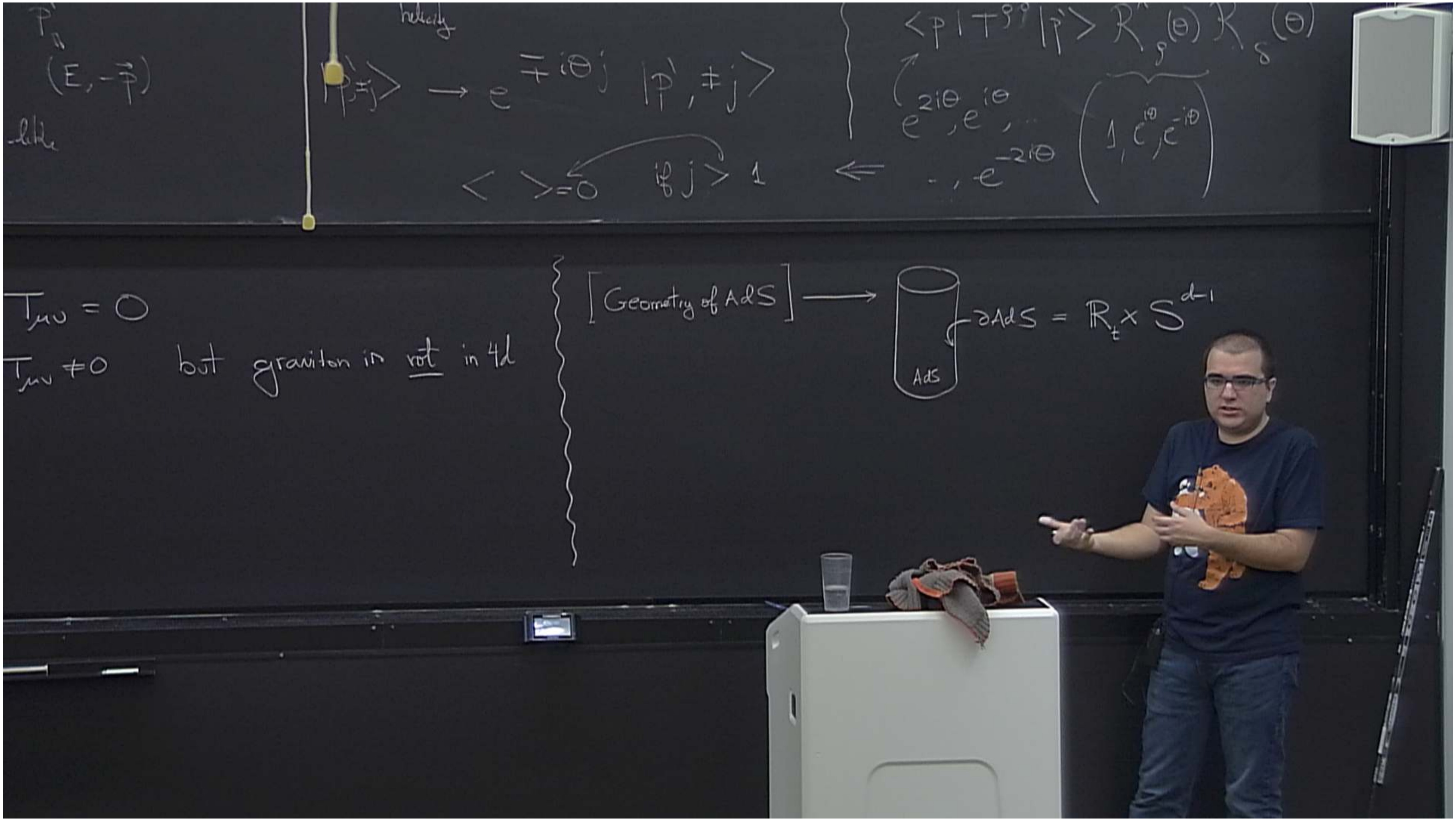


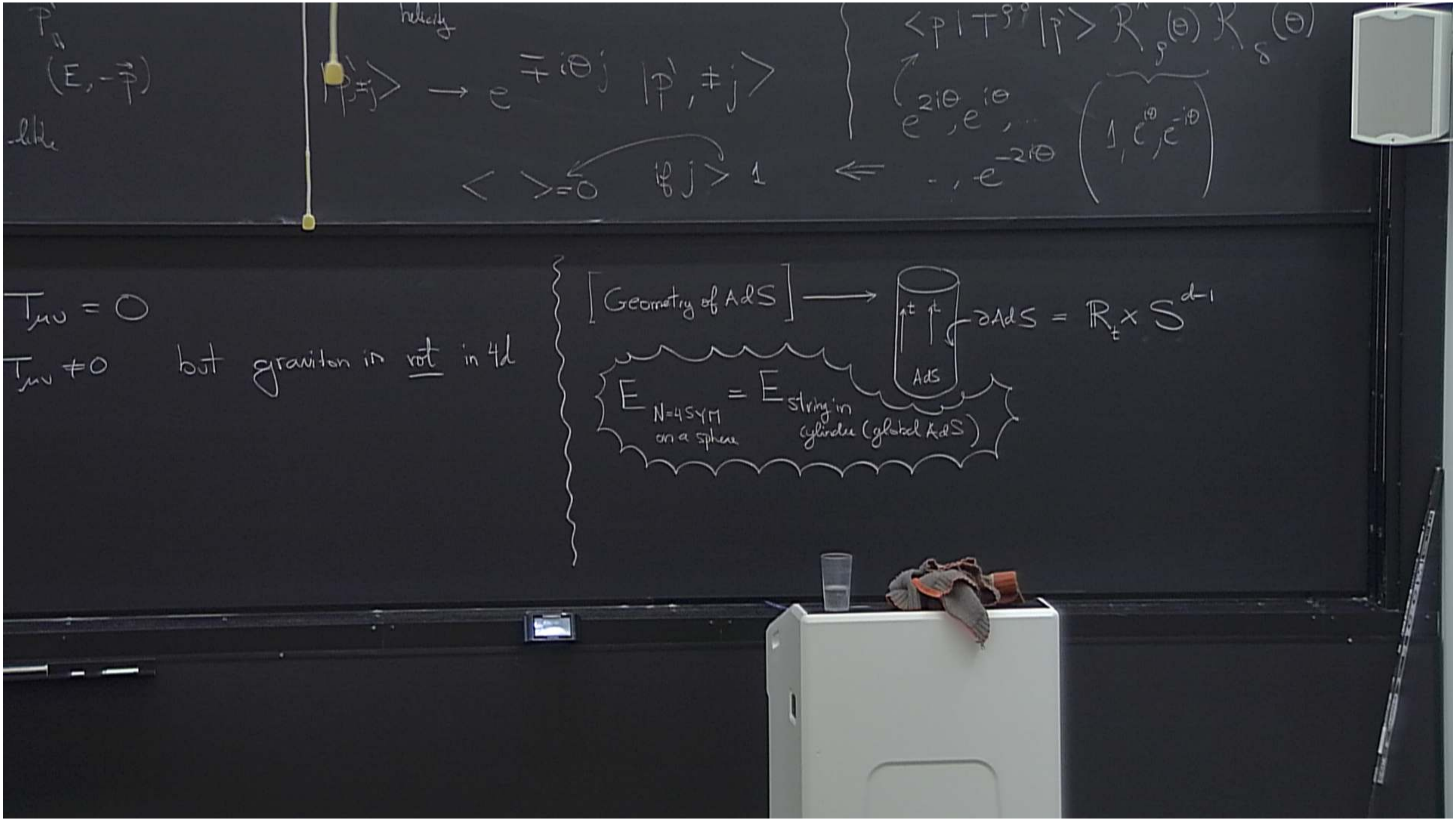

R(θ)
p
(E, p⃗)
p'
(E, −p⃗)
p+p' time-like
|p, ±j>




1 Large N 't Hooft limit
4 Holography S_BH ∝ Area
5 Symmetries
6 Weinberg-Witten
2 gluons open closed duality gravitons
4d N=4 Super Yang-Mills
λ, N
AdS5×S5 superstring theory
3 Brane int vs Background Decoupling argument
Low E for free branes at ∞
AdS5×S5 physics close to brane
free SUGRA
free SUGRA
YM
r<<L
r>>L
ds²AdS5 = r²/L² dx^μ dx_μ + L²/r²




helicity
(E, -p)
< > = 0 if j > 1
Tμν = 0
Tμν ≠ 0 but graviton is not in 4d
[Geometry of AdS] →
∂AdS = Rt × S^d-1
AdS


helicity
(E, -p)
|p, ±j> → e^{∓iθj} |p', ±j>
< > = 0 if j > 1
<p | T^{ρσ} | p'> R(θ) R(θ)
e^{2iθ}, e^{iθ}, ..., e^{-2iθ}
(1, e^{iθ}, e^{-iθ})
T_{μν} = 0
T_{μν} ≠ 0 but graviton is not in 4d
[Geometry of AdS]
∂AdS = R_t × S^{d-1}
AdS
E_{N=4 SYM on a sphere} = E_{string in cylinder (global AdS)}