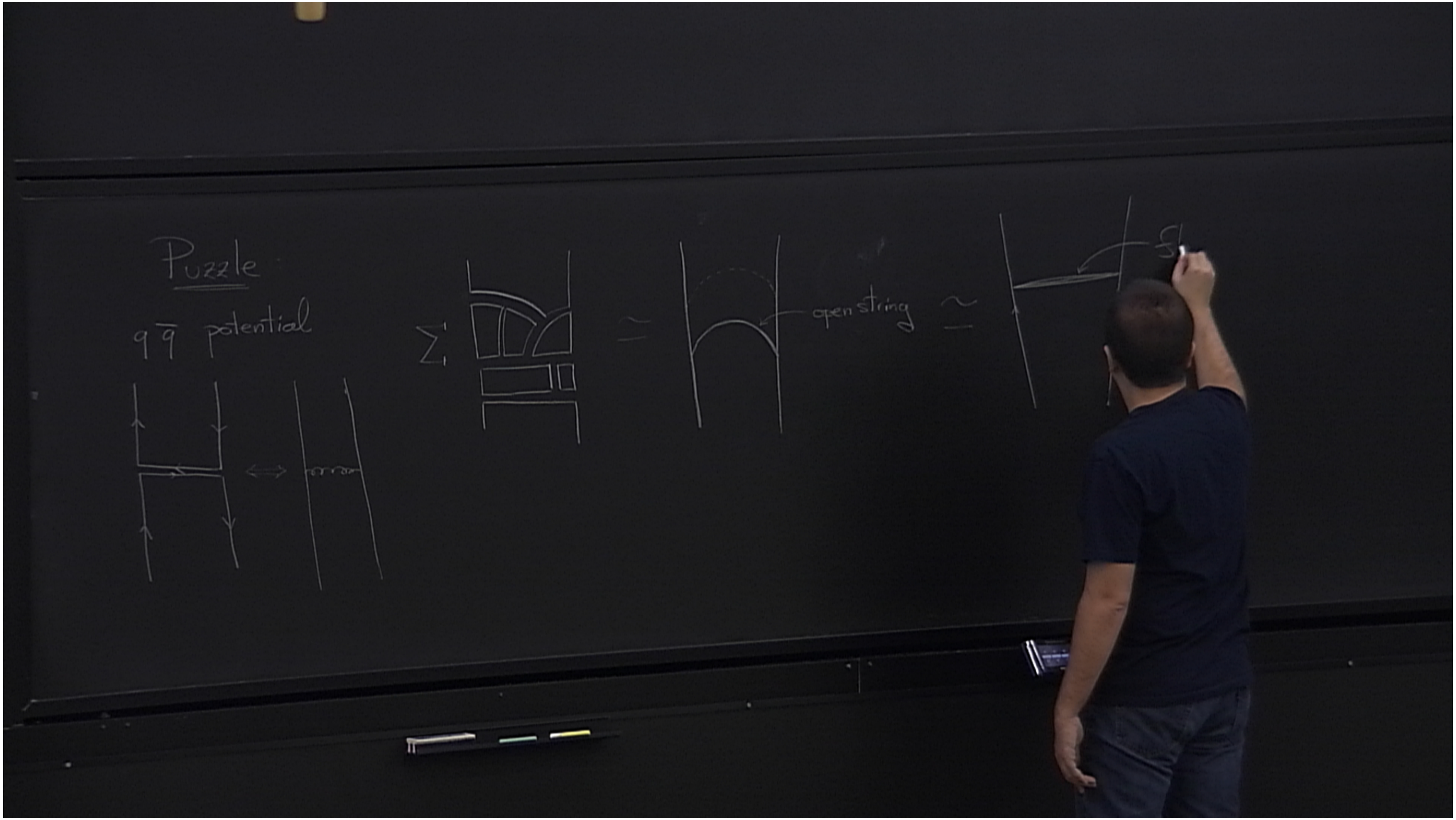
Title: PSI 2015/2016 Explorations in String Theory - Pedro Vieira - 3

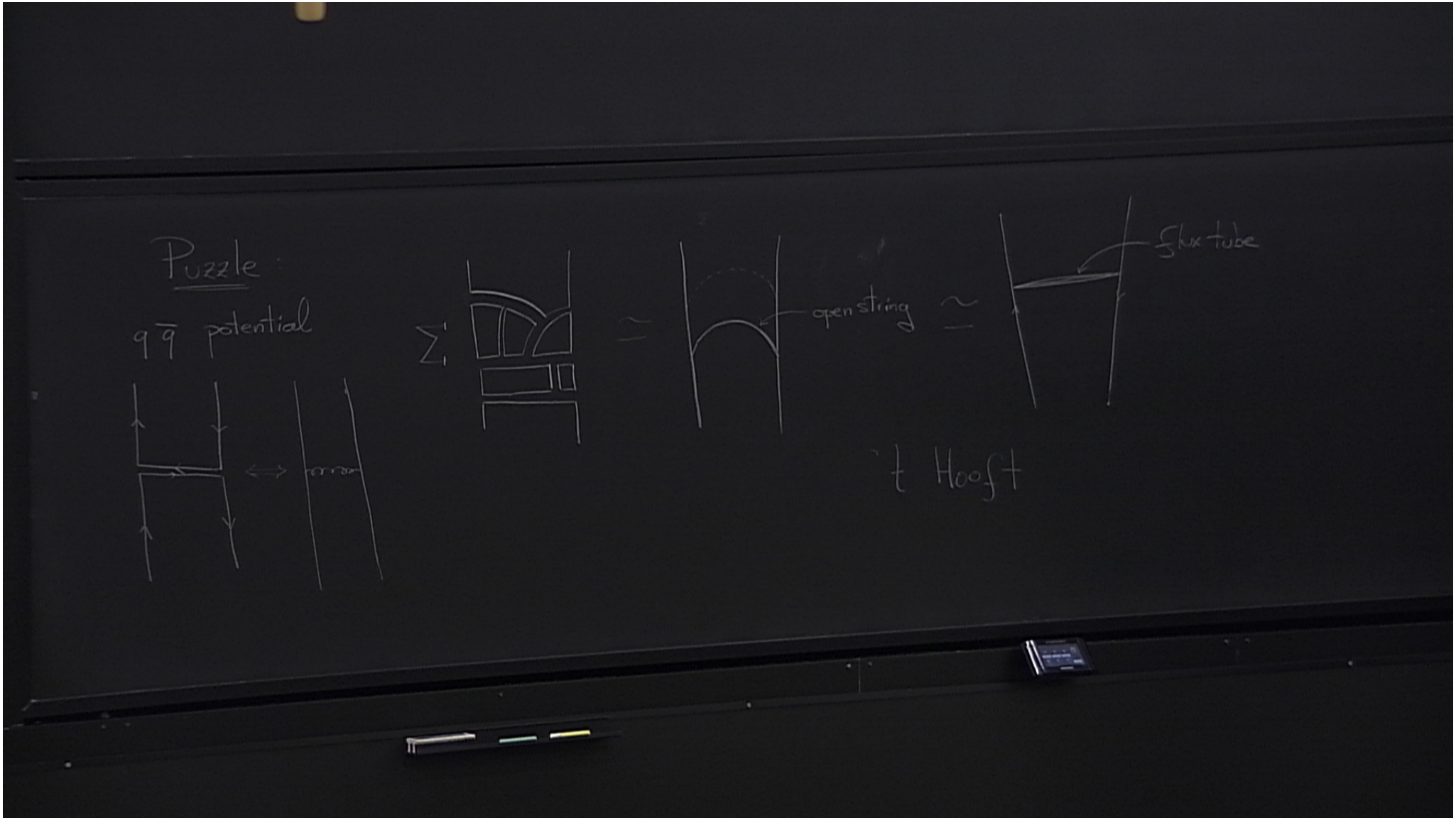
Date: Mar 23, 2016 11:30 AM

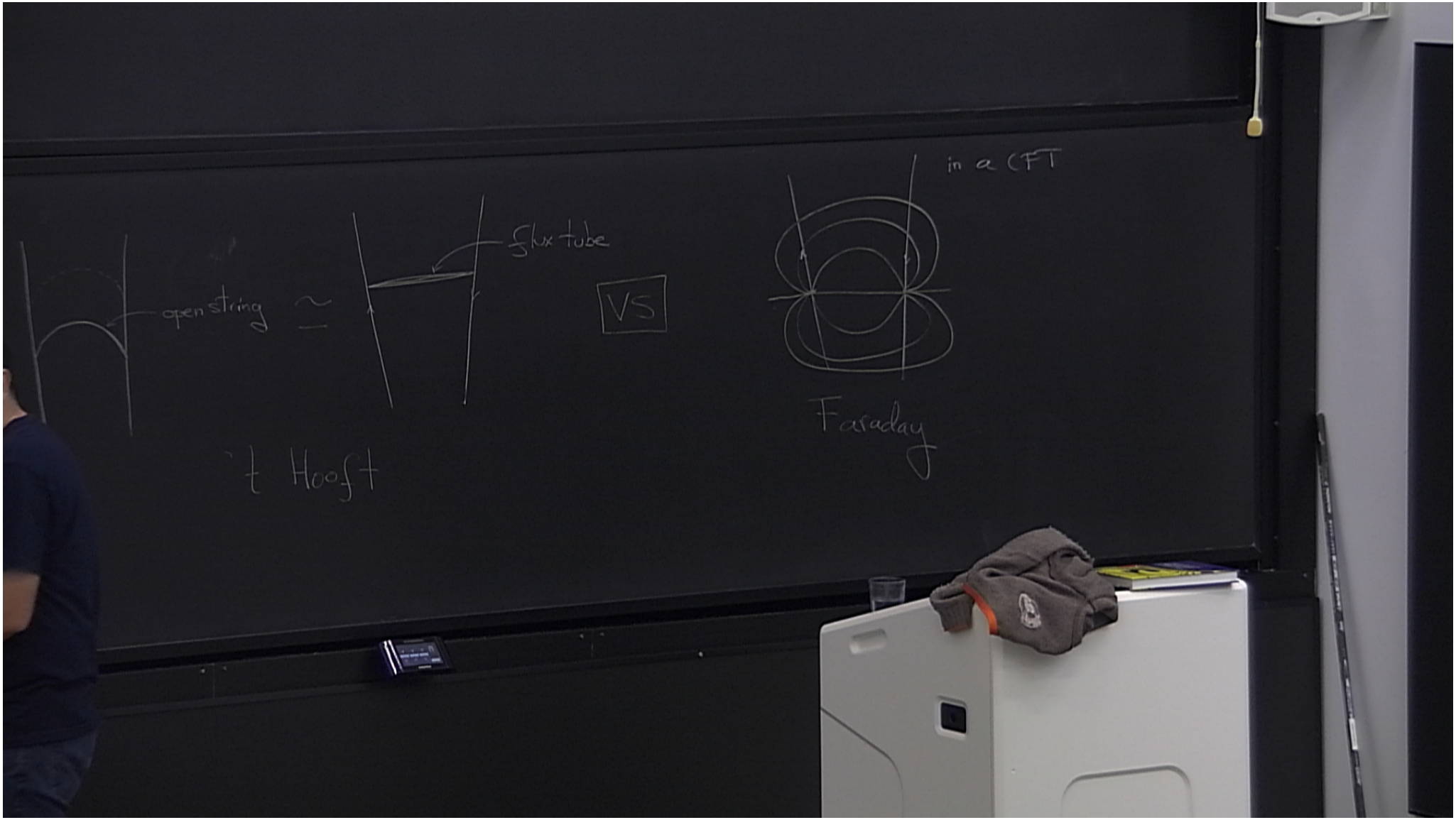
URL: http://pirsa.org/16030065

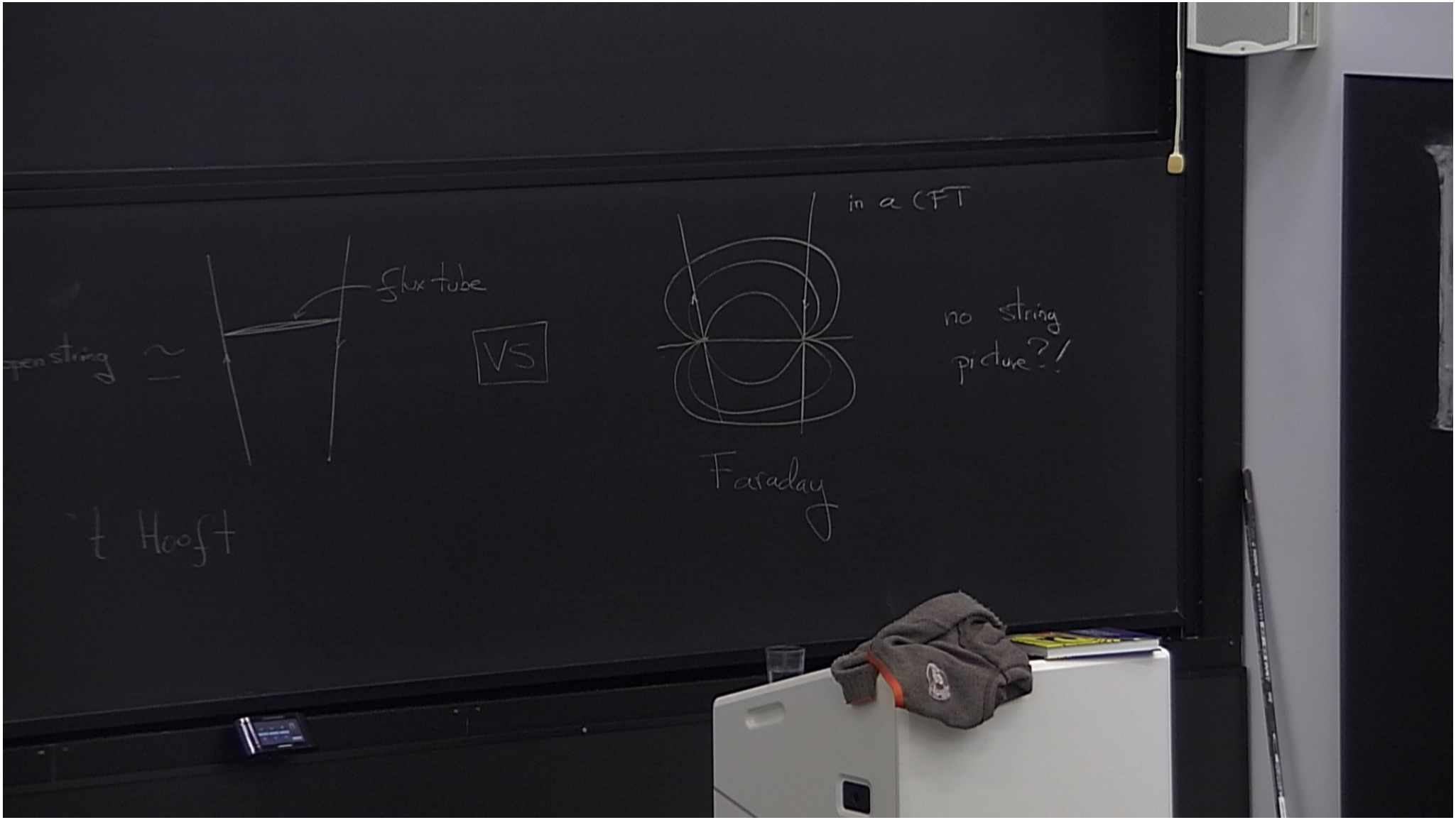
Abstract:

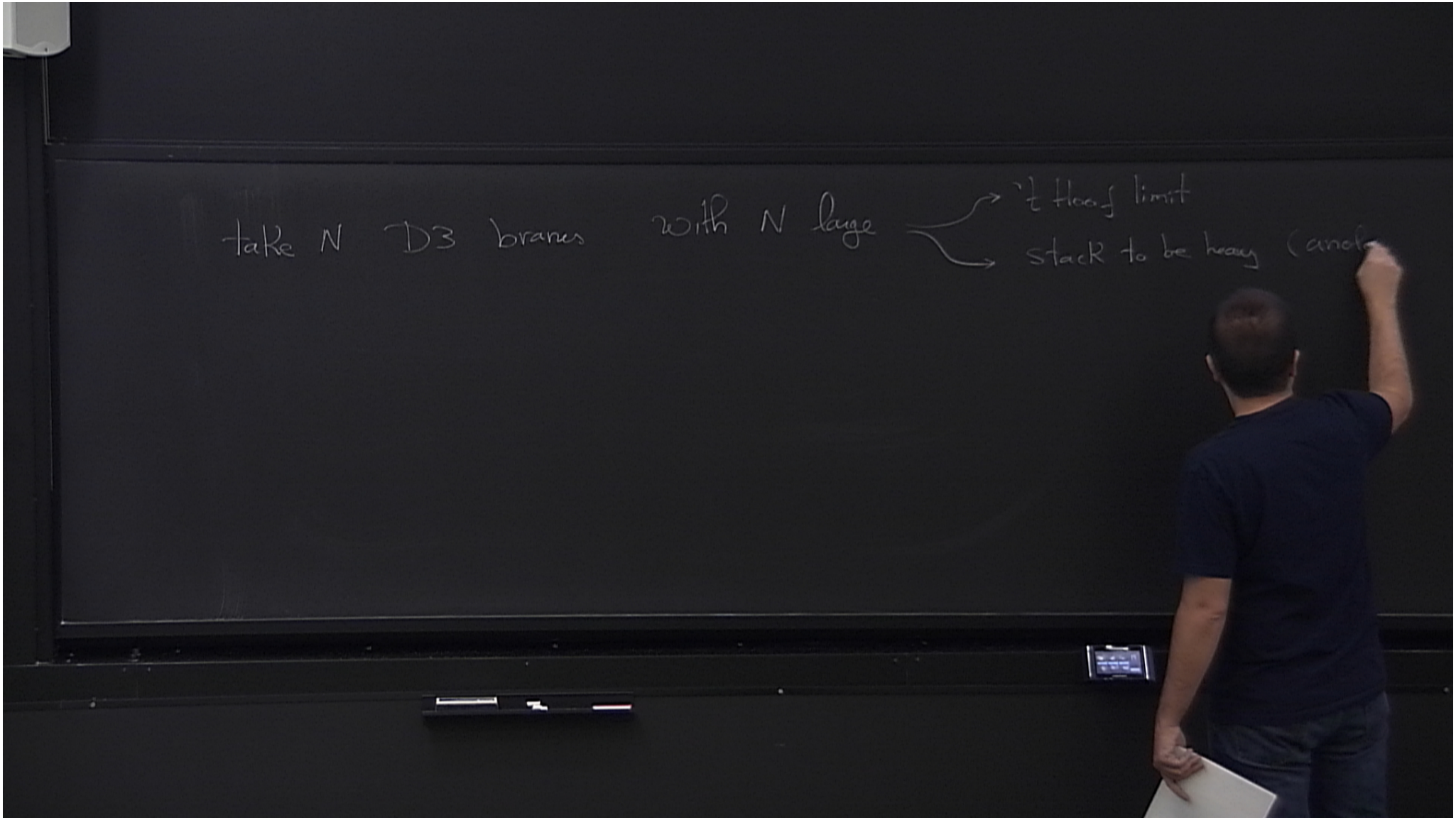

open string (like gluon)
closed string (like graviton)
1 Large N /M like theories
look like string theory
2 Open / Closed string dualities
lost at Gauge / Gravity dualities
open string
closed string


Puzzle
$q\bar{q}$ potential
open string


Puzzle
$q\bar{q}$ potential
open string
flux tube
't Hooft

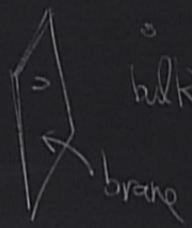

open string
flux tube
VS
in a CFT
't Hooft
Faraday


open string
flux tube
VS
in a CFT
no string picture?!
Faraday
't Hooft

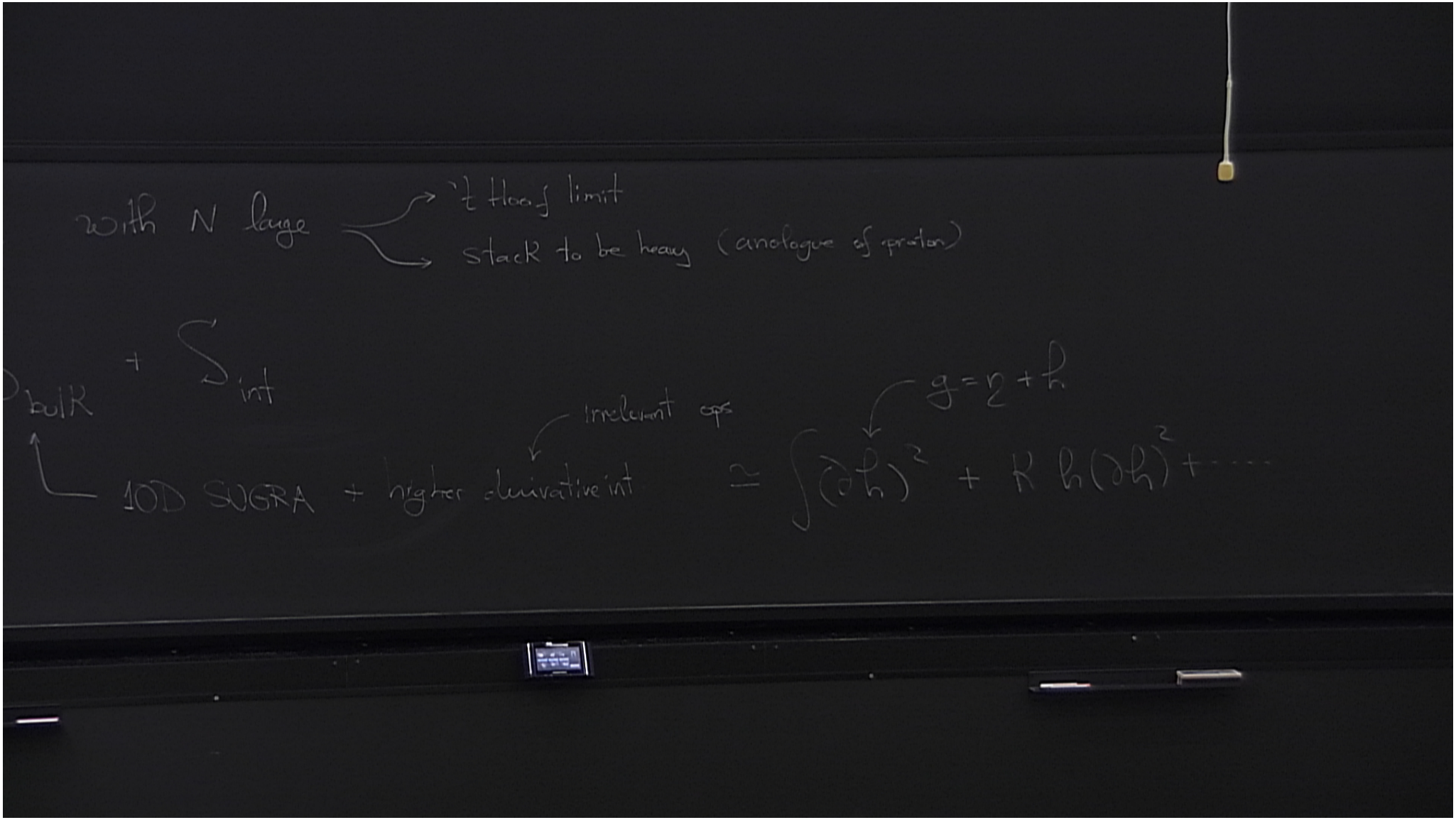

take N D3 branes with N huge
't Hooft limit
stack to be heavy

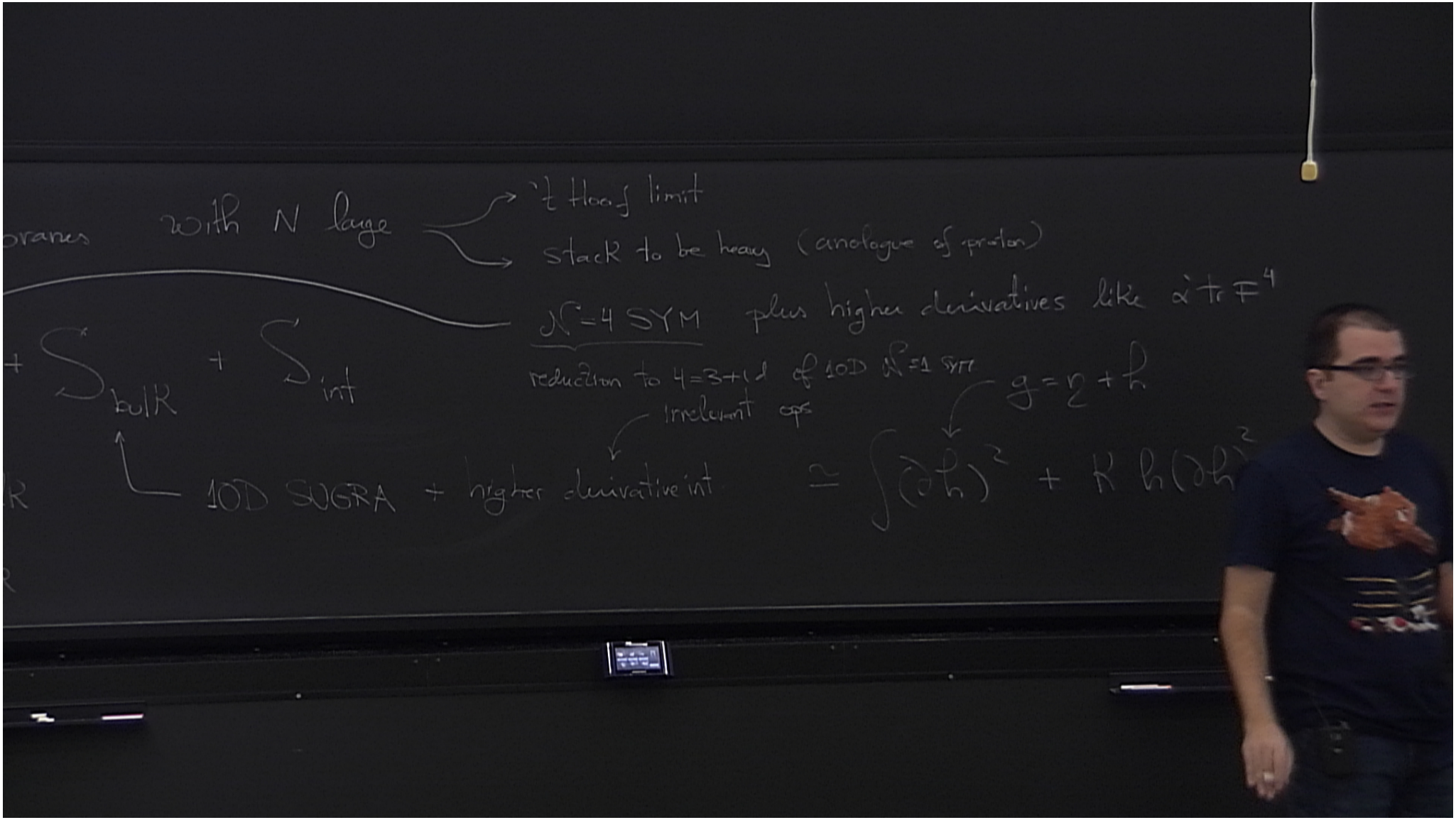
take N D3 branes with N large → 't Hooft limit
→ stack to be heavy (anal

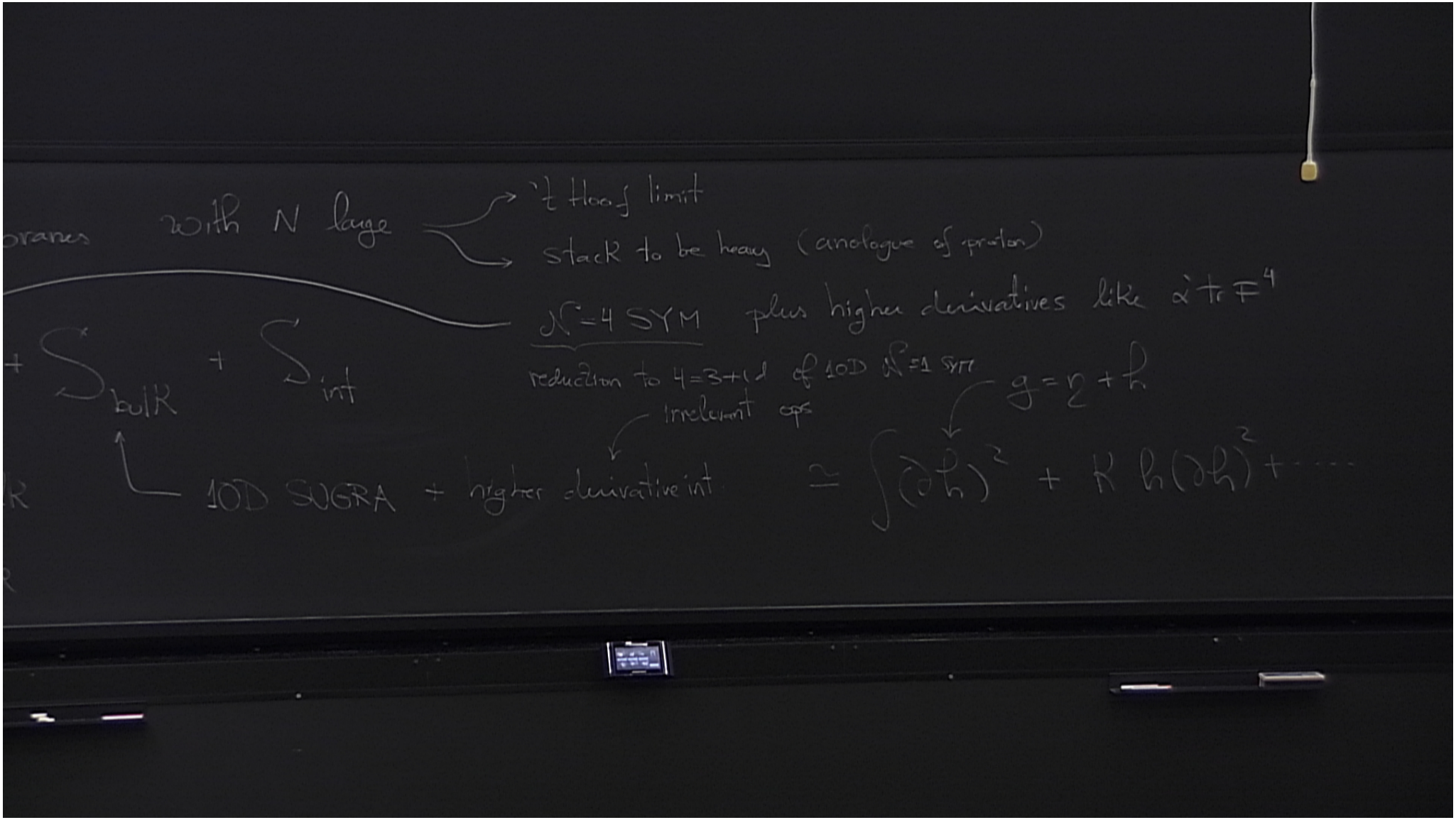
$$S = S_{brane} + S_{bulk} + S_{int}$$




bulk → 10D SUGRA + higher derivative int


with N large
't Hooft limit
stack to be heavy (analogue of proton)
$S_{bulk}$ + $S_{int}$
10D SUGRA + higher derivative int
irrelevant ops
$g = r_2 + h$
$\simeq \int (\partial h)^2 + K h (\partial h)^2 + \cdots$


't Hooft limit
stack to be heavy (analogue of proton)
plus higher derivatives like $\alpha' \mathrm{tr} F^4$
reduction to 4=3+1 d of 10D $\mathcal{N}=1$ SYM
irrelevant ops
$g = r^2 + h$
10D SUGRA + higher derivative int
$\simeq \int (\partial h)^2 + R\, h (\partial h)^2$


branes with N large
't Hooft limit
stack to be heavy (analogue of proton)
$\mathcal{N}=4$ SYM plus higher derivatives like $\alpha' \mathrm{tr} F^4$
reduction to 4=3+1 d of 10D $\mathcal{N}=1$ SYM
$g = v + h$
irrelevant ops
$+ S_{bulk} + S_{int}$
10D SUGRA + higher derivative int
$\simeq \int (\partial h)^2 + K h (\partial h)^2 + \cdots$

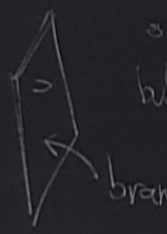
N D3 branes with N large → 't Hooft limit
→ stack to be heavy (analogue of proton)

$S = S_{brane} + S_{bulk} + S_{int}$

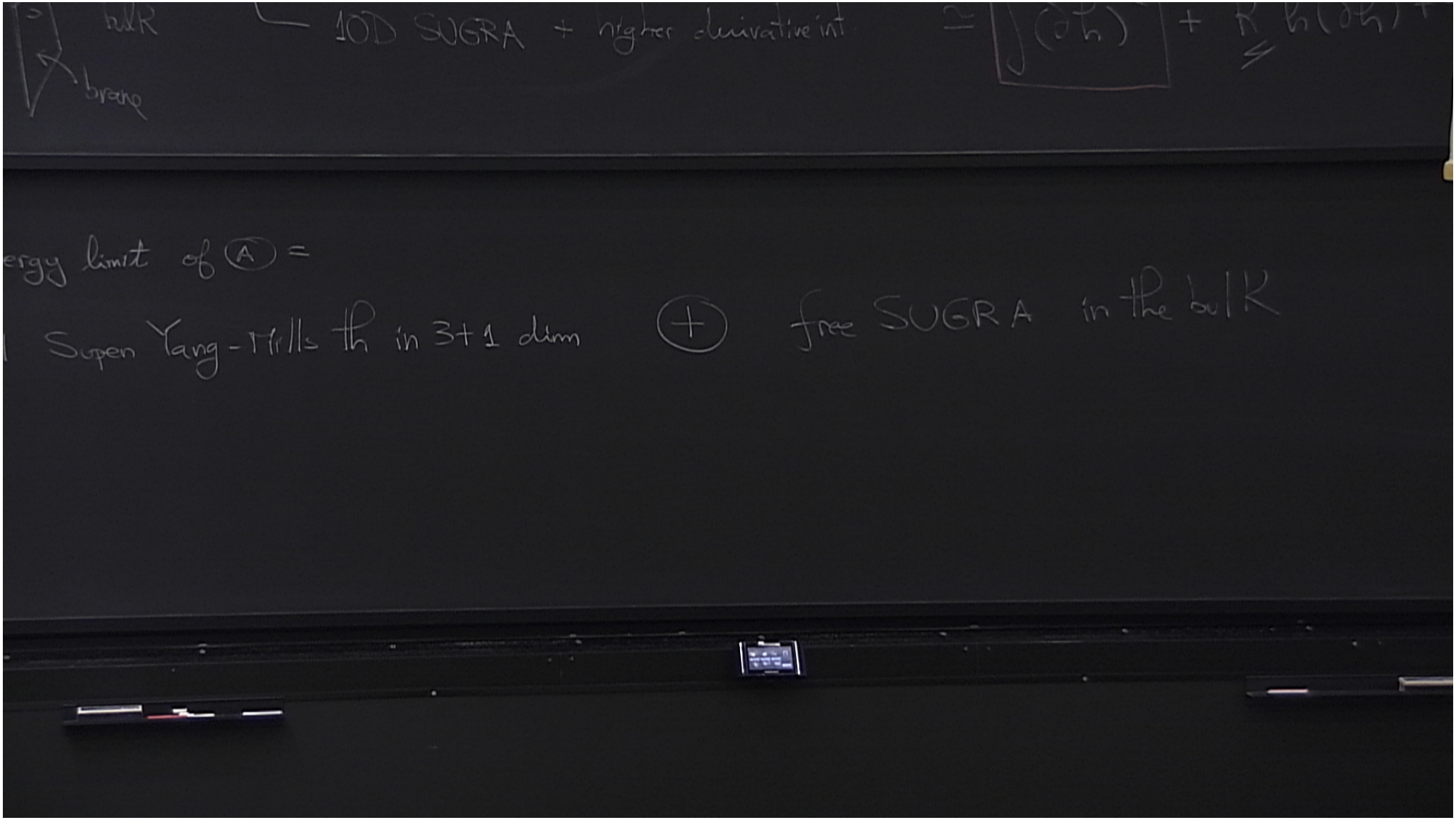
$\mathcal{N}=4$ SYM plus higher derivatives like $\alpha' \mathrm{tr} F$

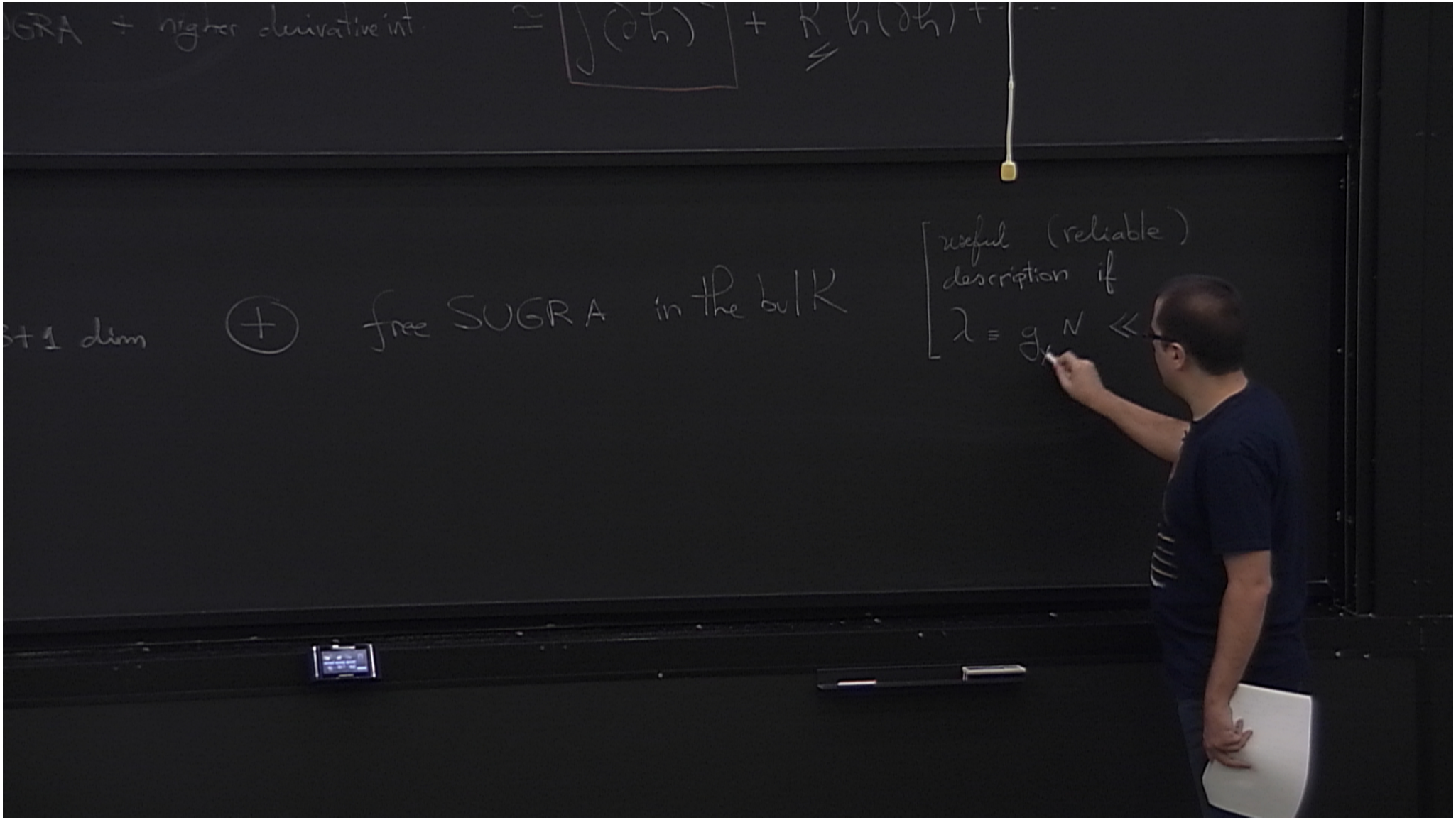
reduction to $4=3+1$ d of 10D $\mathcal{N}=1$ SYM

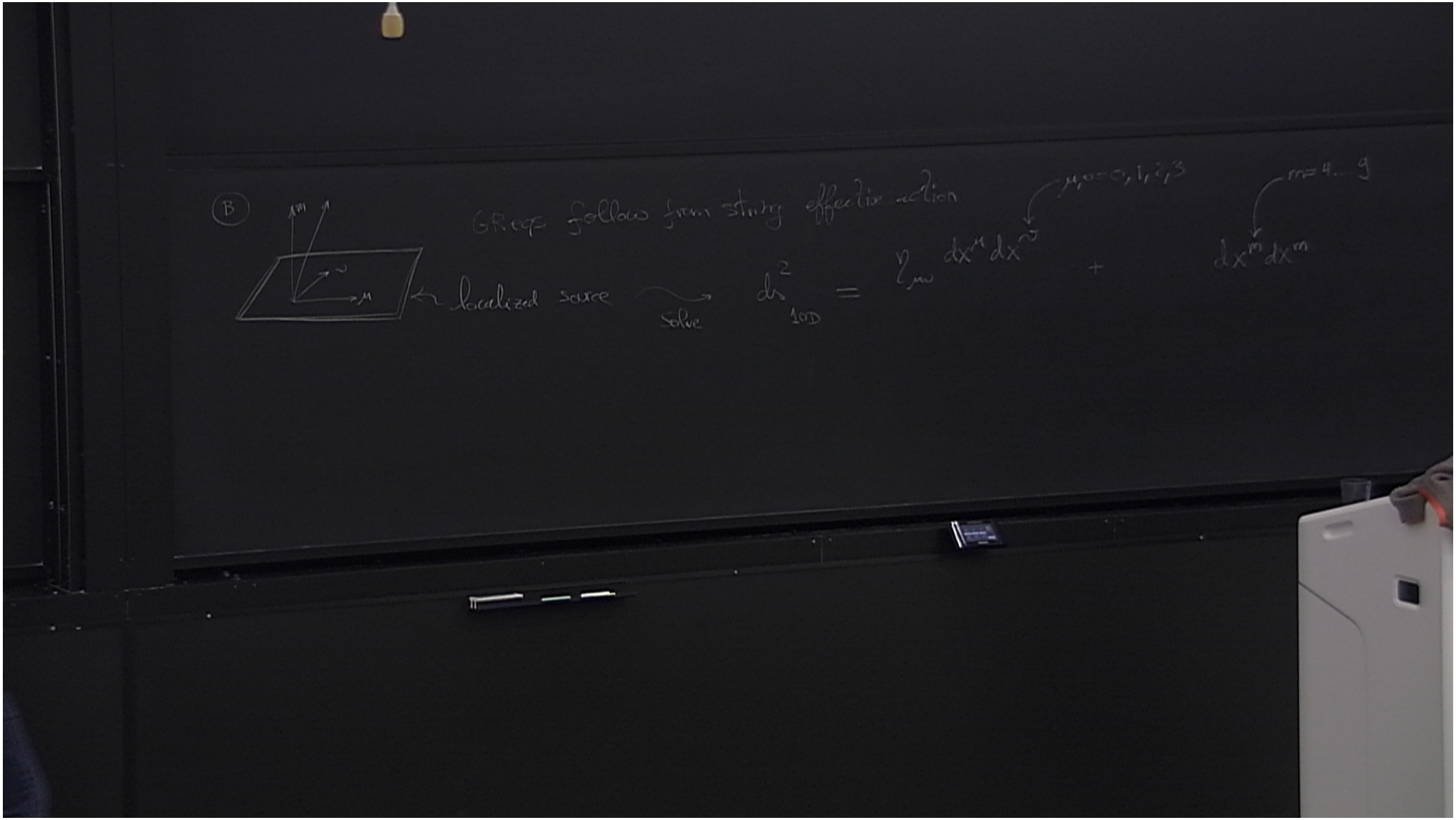
$g = r^2 + h$

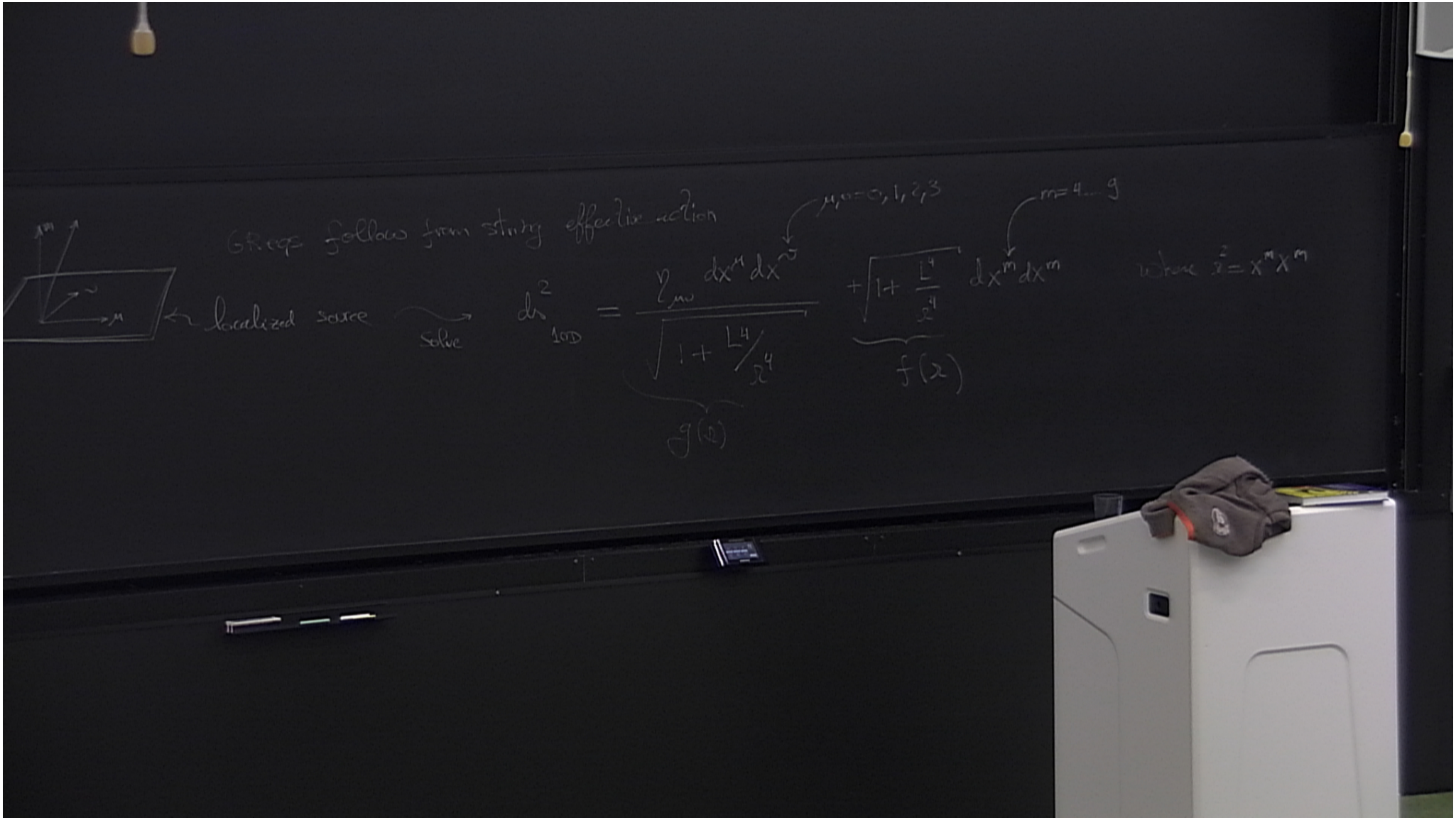


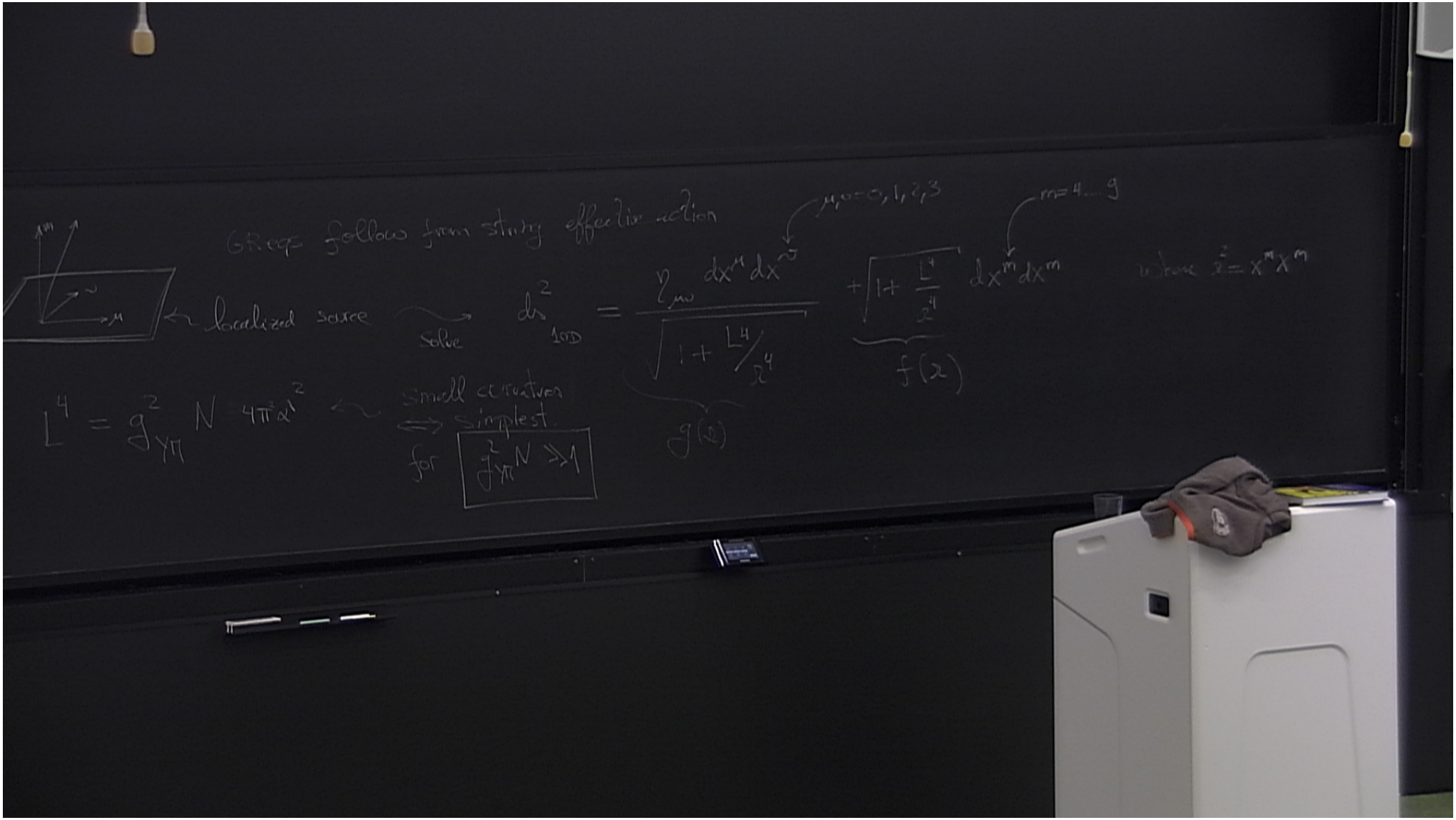

bulk → 10D SUGRA + higher derivative int (irrelevant ops) $\simeq \int (\partial h)^2 + K h (\partial h)^2$

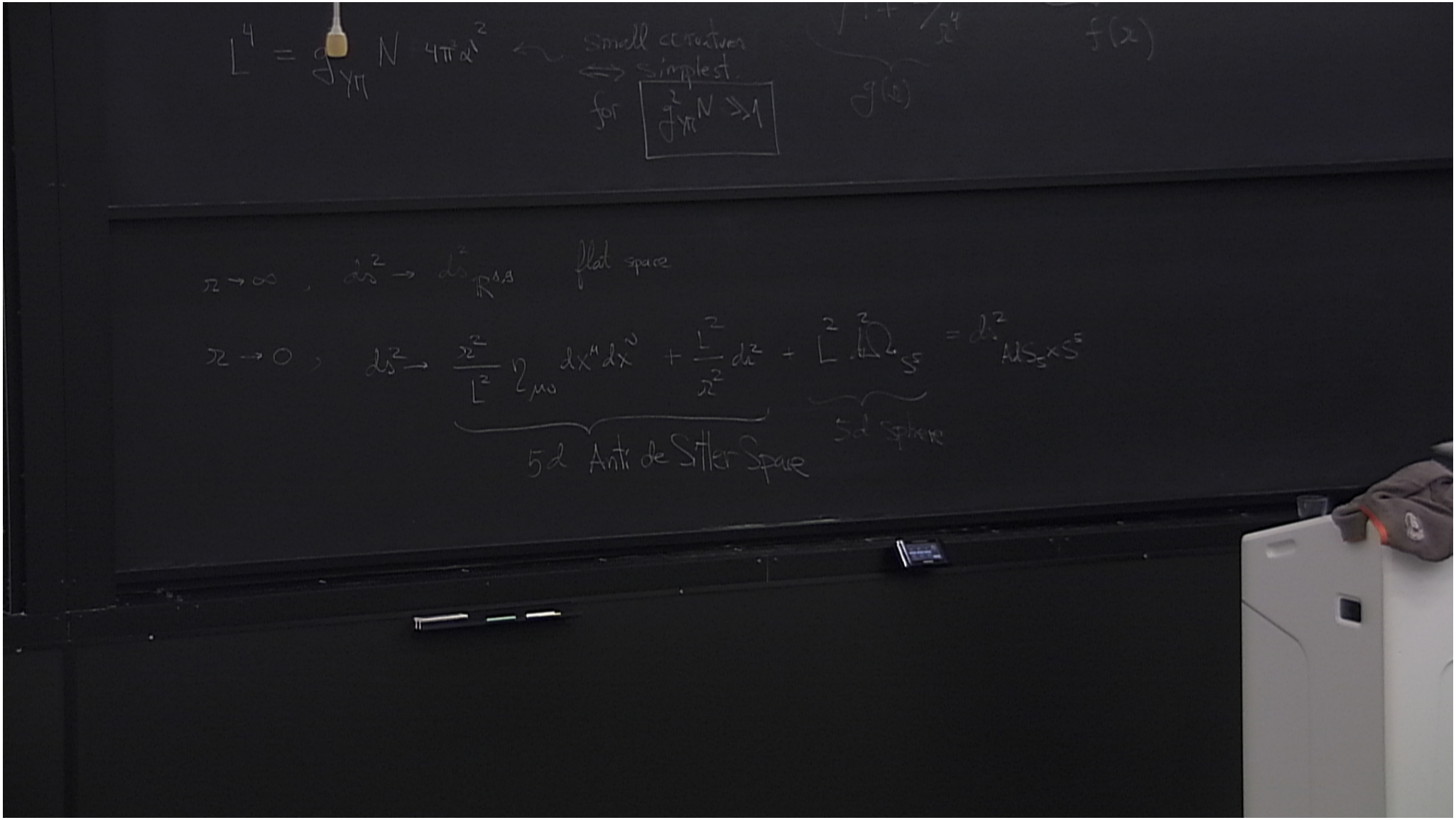

bulk
brane
10D SUGRA + higher derivative int
ergy limit of (A) =
Super Yang-Mills th in 3+1 dim
free SUGRA in the bulk

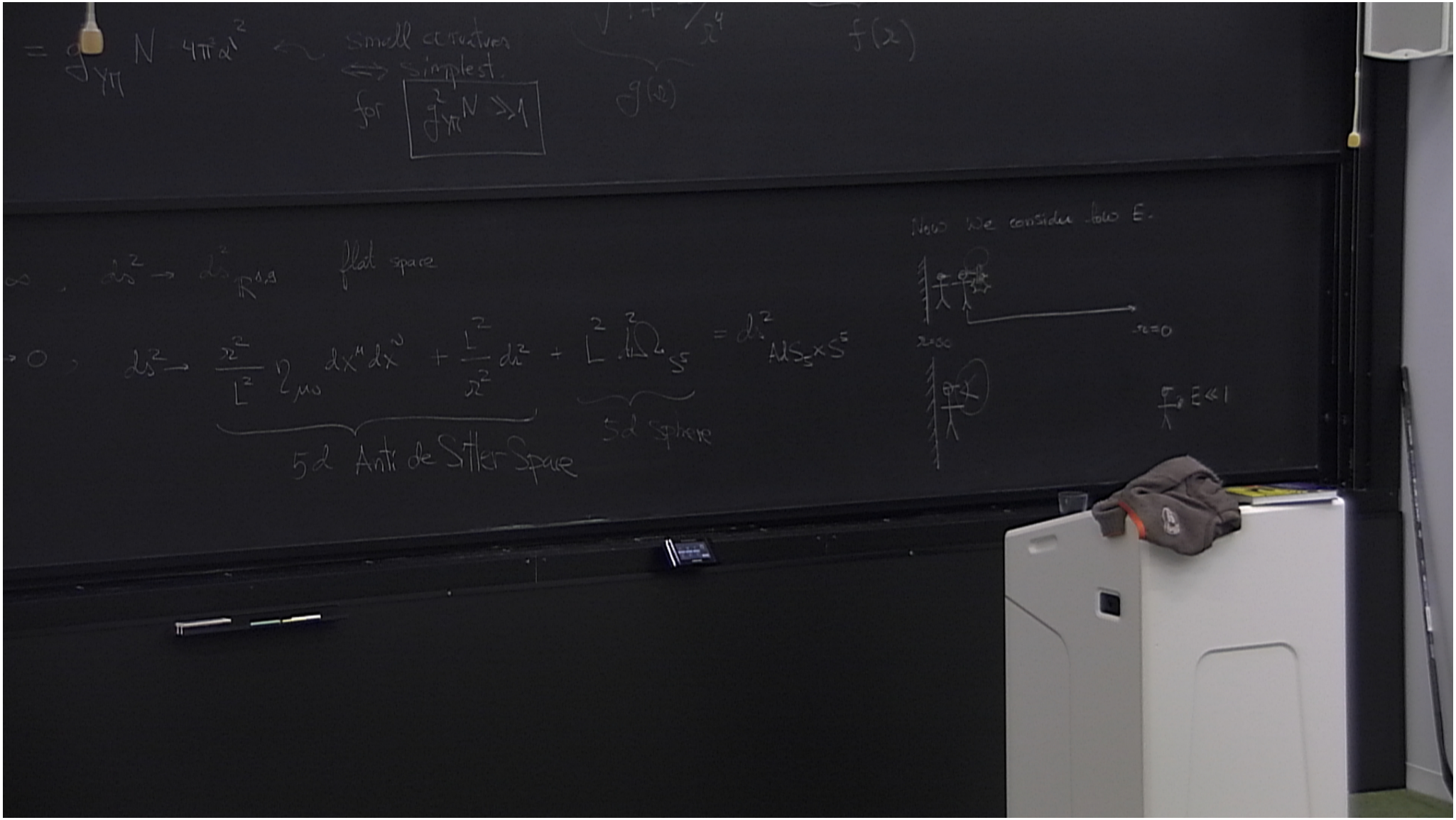

GRA + higher derivative int
+ free SUGRA in the bulk
useful (reliable) description if

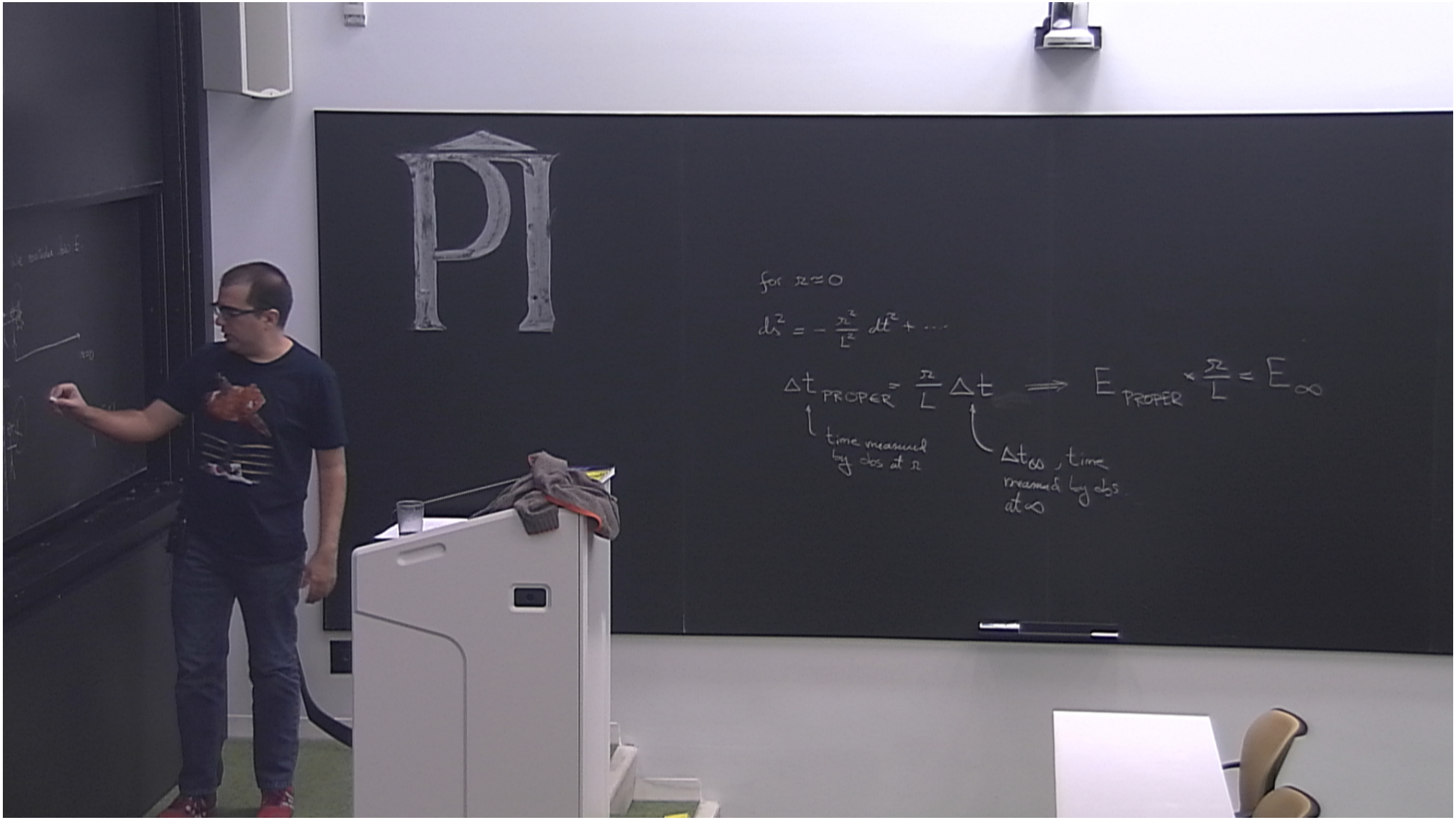

B
GR eqs follows from string effective action
localized source
solve
$ds^2_{10D} = \eta_{\mu\nu} dx^\mu dx^\nu + dx^m dx^m$
$\mu = 0, 1, 2, 3$
$m = 4 \dots 9$

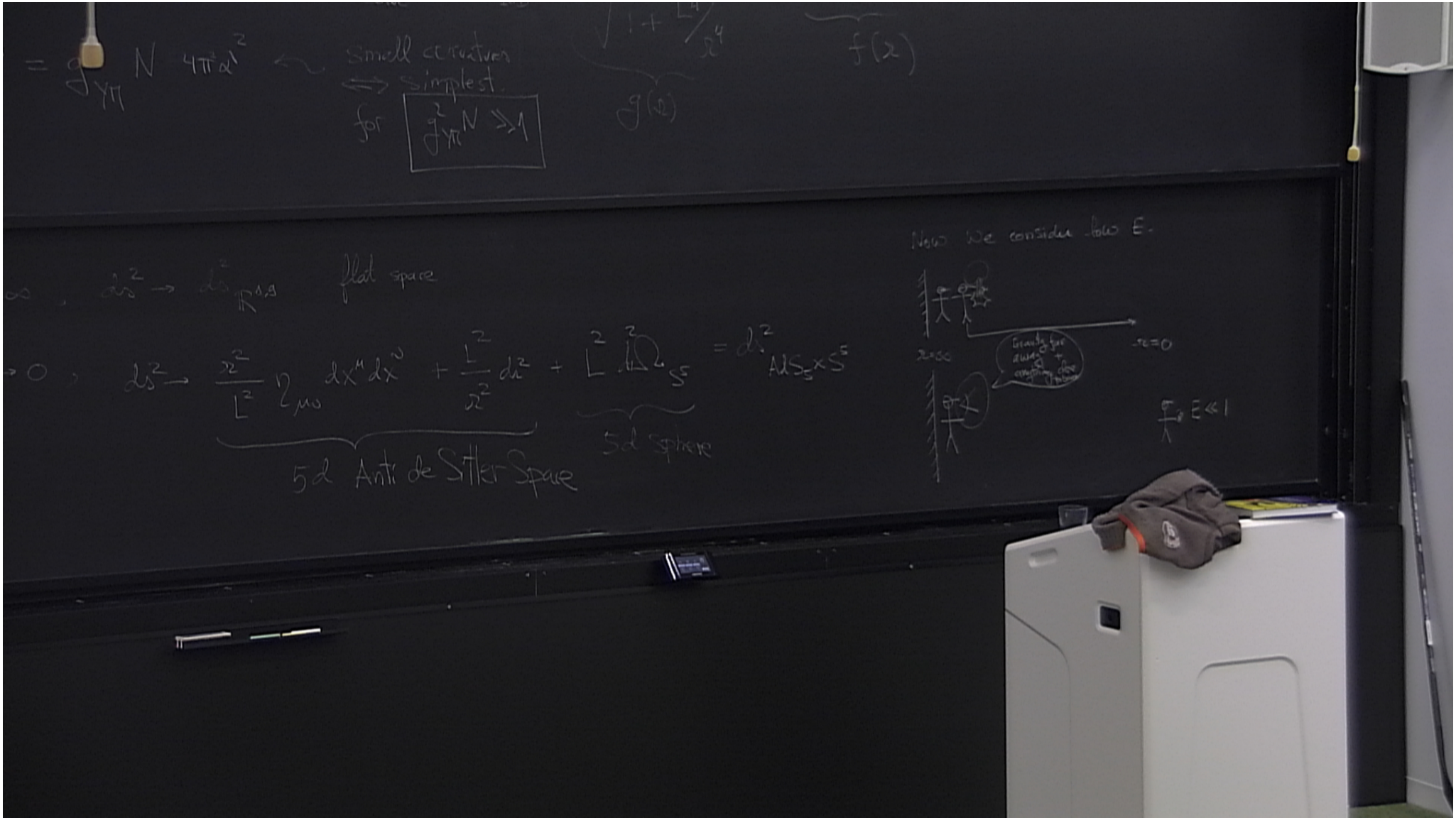

Gravity follows from string effective action
localized source
solve
$ds^2_{10D} = \frac{\eta_{\mu\nu}\,dx^\mu dx^\nu}{\sqrt{1+L^4/x^4}} + \sqrt{1+\frac{L^4}{x^4}}\,dx^m dx^m$
$\mu,\nu = 0,1,2,3$
$m = 4 \ldots 9$
where $x^2 = x^m x^m$
$g(x)$
$f(x)$

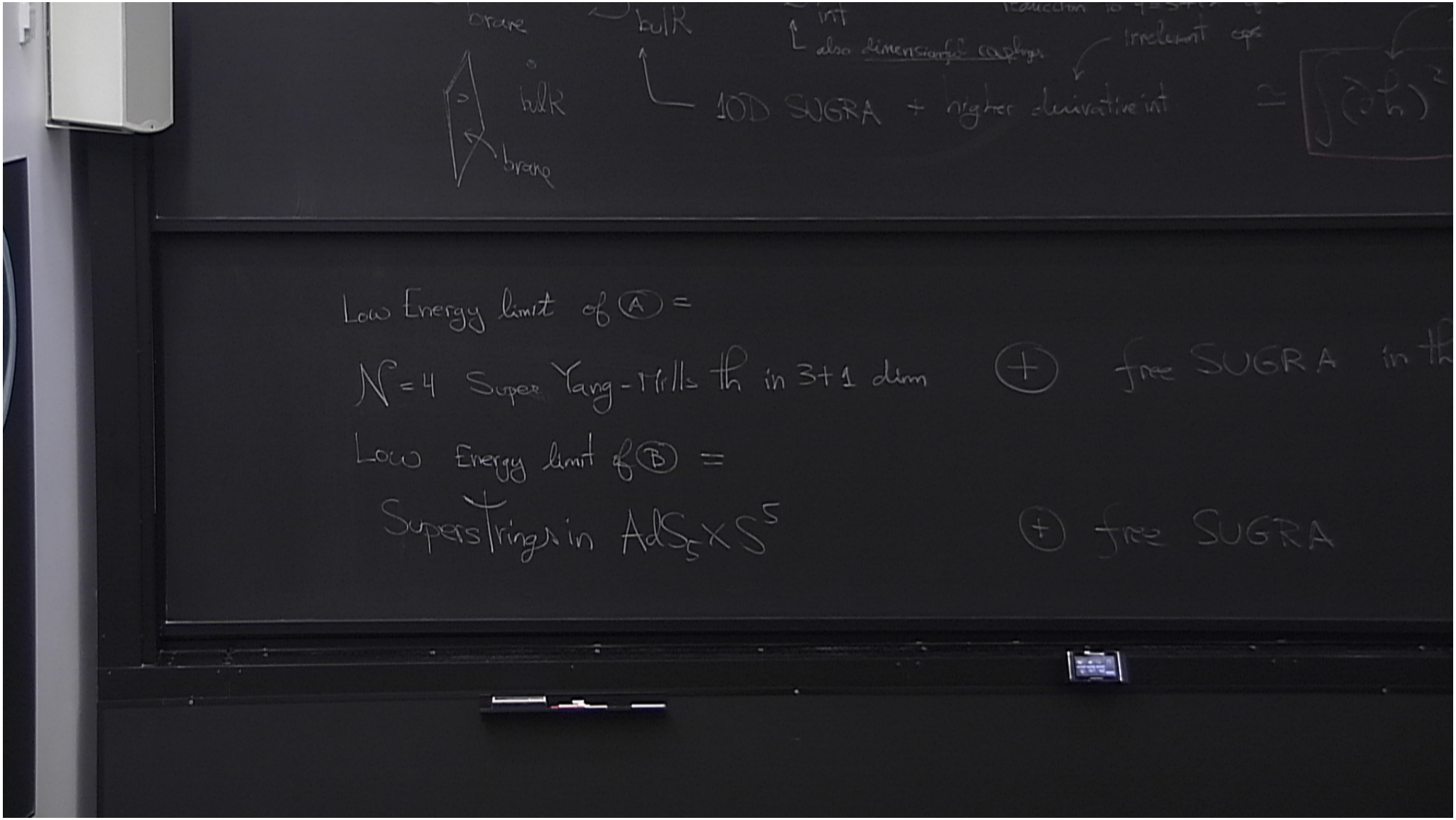

Greens follow from string effective action
localized source
solve
$ds^2_{10D} = \frac{\eta_{\mu\nu} dx^\mu dx^\nu}{\sqrt{1+\frac{L^4}{z^4}}} + \sqrt{1+\frac{L^4}{z^4}}\, dx^m dx^m$
$\mu,\nu = 0,1,2,3$
$m = 4 \ldots 9$
where $z^2 = x^m x^m$
$f(z)$
$g(z)$
$L^4 = g^2_{YM} N \, 4\pi\alpha'^2$
small curvature
$\Leftrightarrow$ simplest
for $g^2_{YM} N \gg 1$

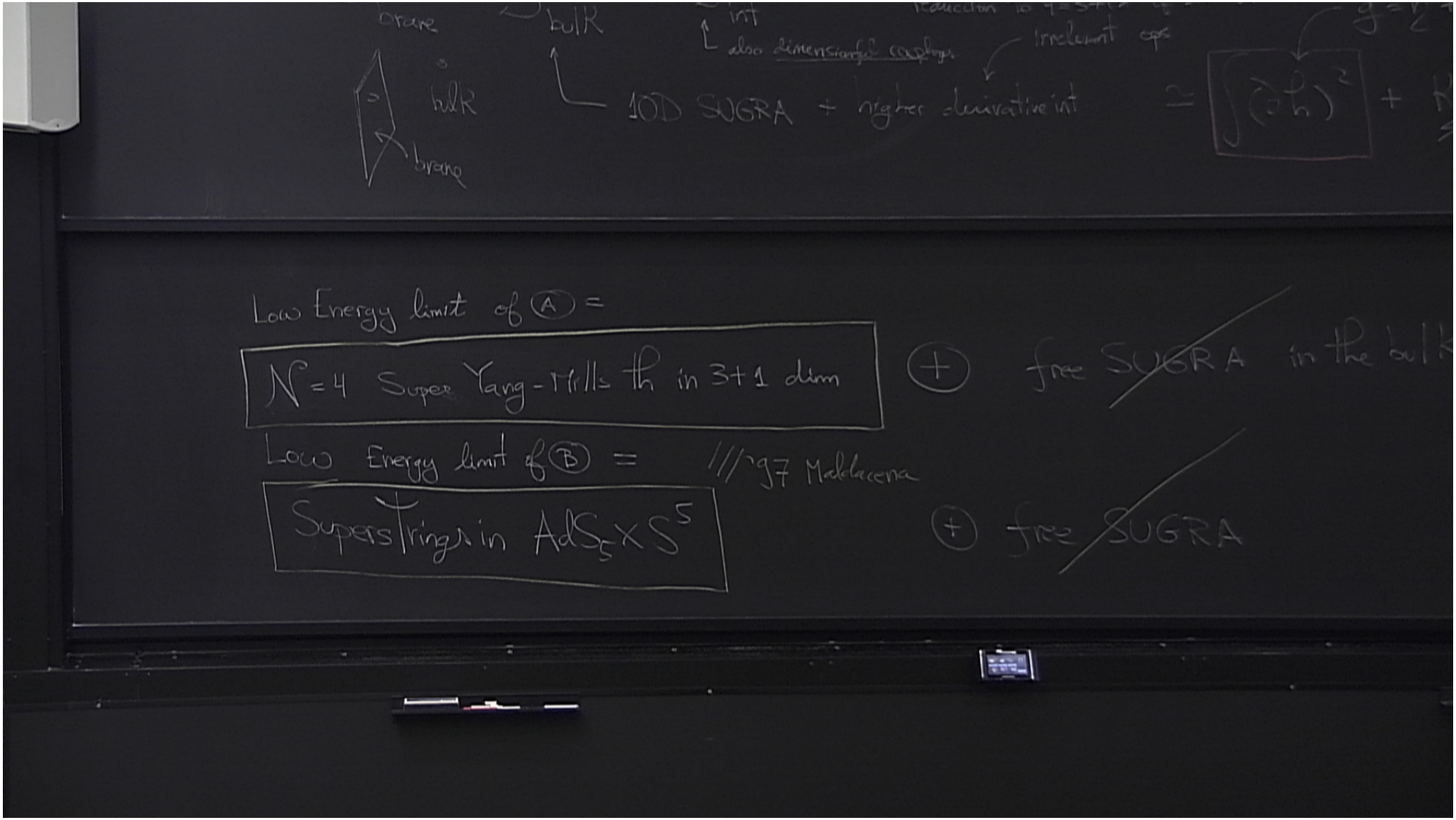

$L^4 = g_{YM} N 4\pi\alpha'^2$
Small curvature
$\Leftrightarrow$ simplest
for $g_{YM}^2 N \gg 1$
$f(x)$
$g(x)$
$z \to \infty$, $ds^2 \to ds^2_{\mathbb{R}^{3,1}}$ flat space
$z \to 0$, $ds^2 \to \frac{z^2}{L^2} \eta_{\mu\nu} dx^\mu dx^\nu + \frac{L^2}{z^2} dz^2 + L^2 d\Omega_{S^5}$
$= ds^2_{AdS_5 \times S^5}$
5d Anti de Sitter Space
5d Sphere

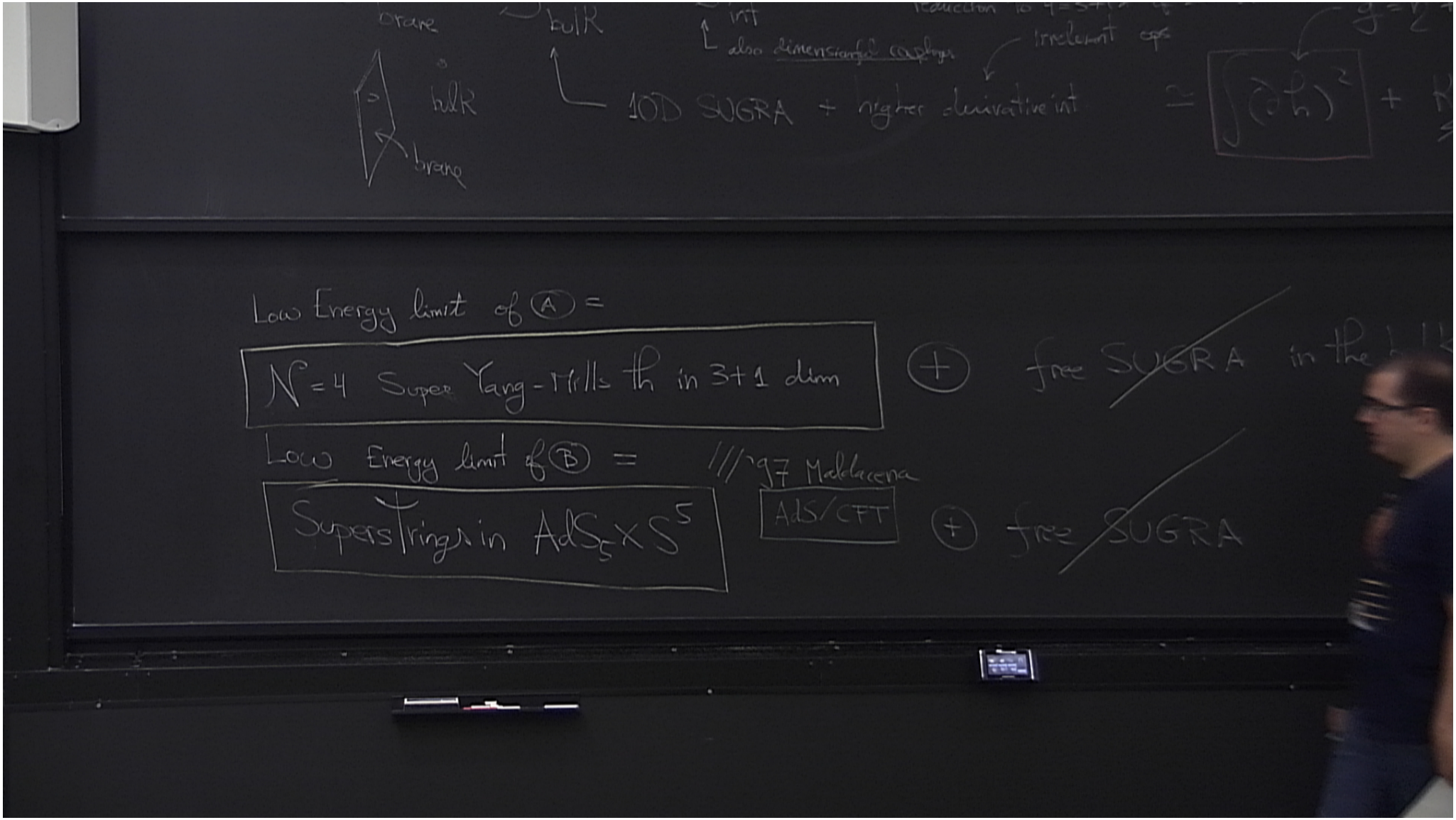

small curvature
simplest
for
flat space
Now we consider low E.
E≪1
5d Anti de Sitter Space
5d sphere

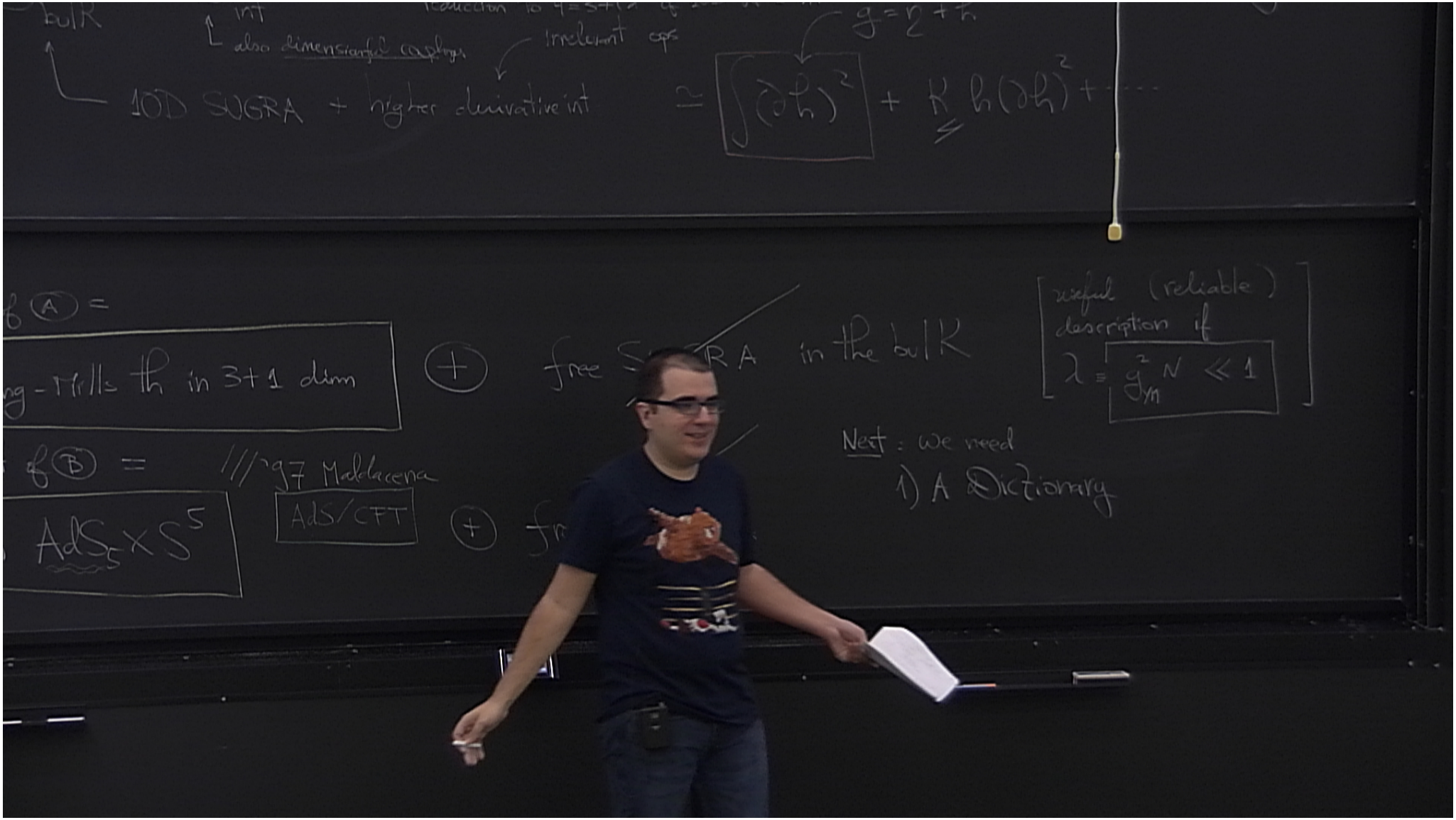

for $r \simeq 0$
$ds^2 = -\frac{r^2}{L^2} dt^2 + \dots$
$\Delta t_{PROPER} = \frac{r}{L} \Delta t \Rightarrow E_{PROPER} \times \frac{r}{L} = E_\infty$
time measured by obs at $r$
$\Delta t_\infty$, time measured by obs at $\infty$

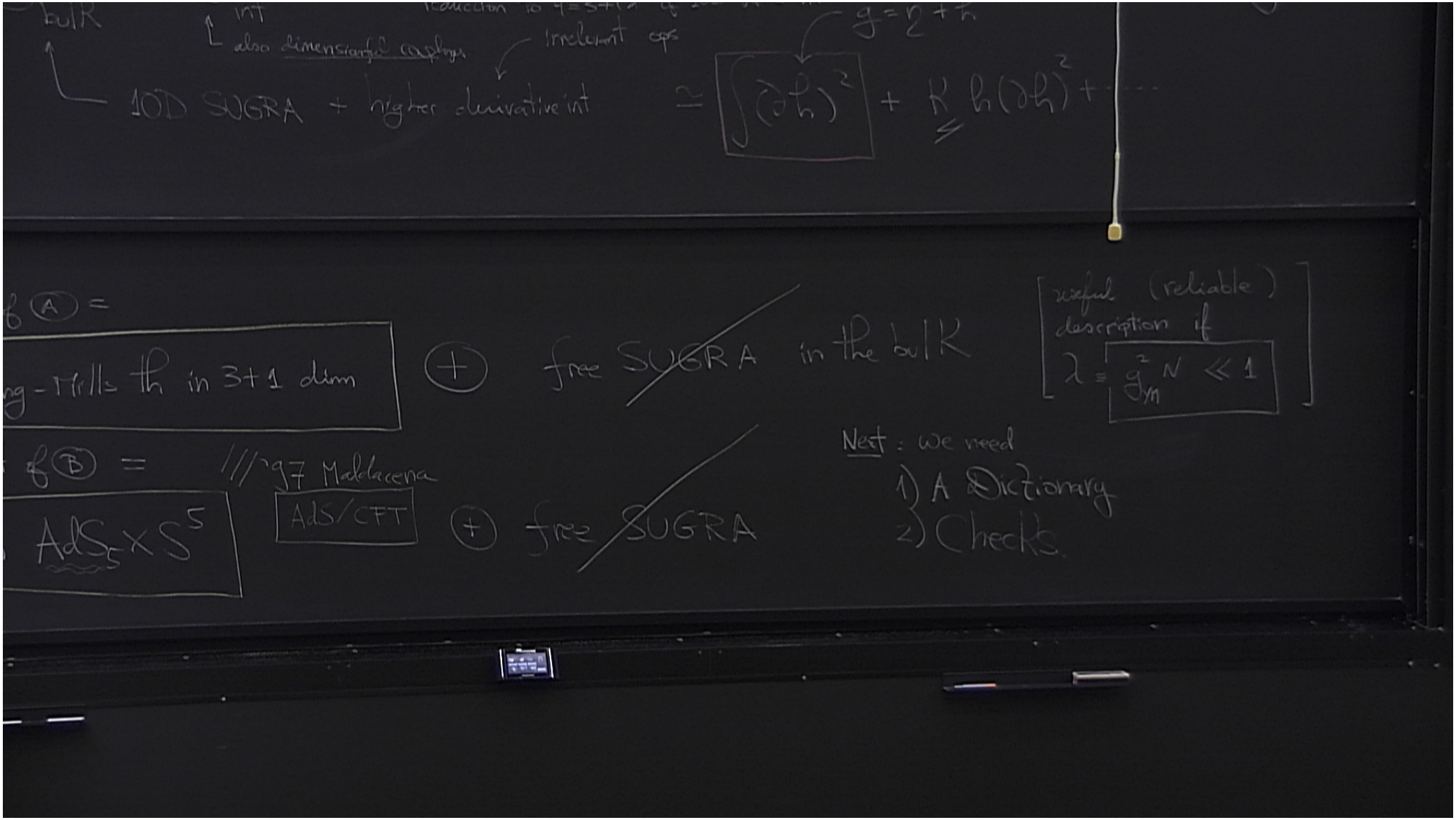

small curvatures
⟺ simplest
for $g_{YM}^2 N \gg 1$
$f(x)$
$g(x)$
flat space
$\to AdS_5 \times S^5$
5d Anti de Sitter Space
5d sphere
Now we consider low E.
$E \ll 1$

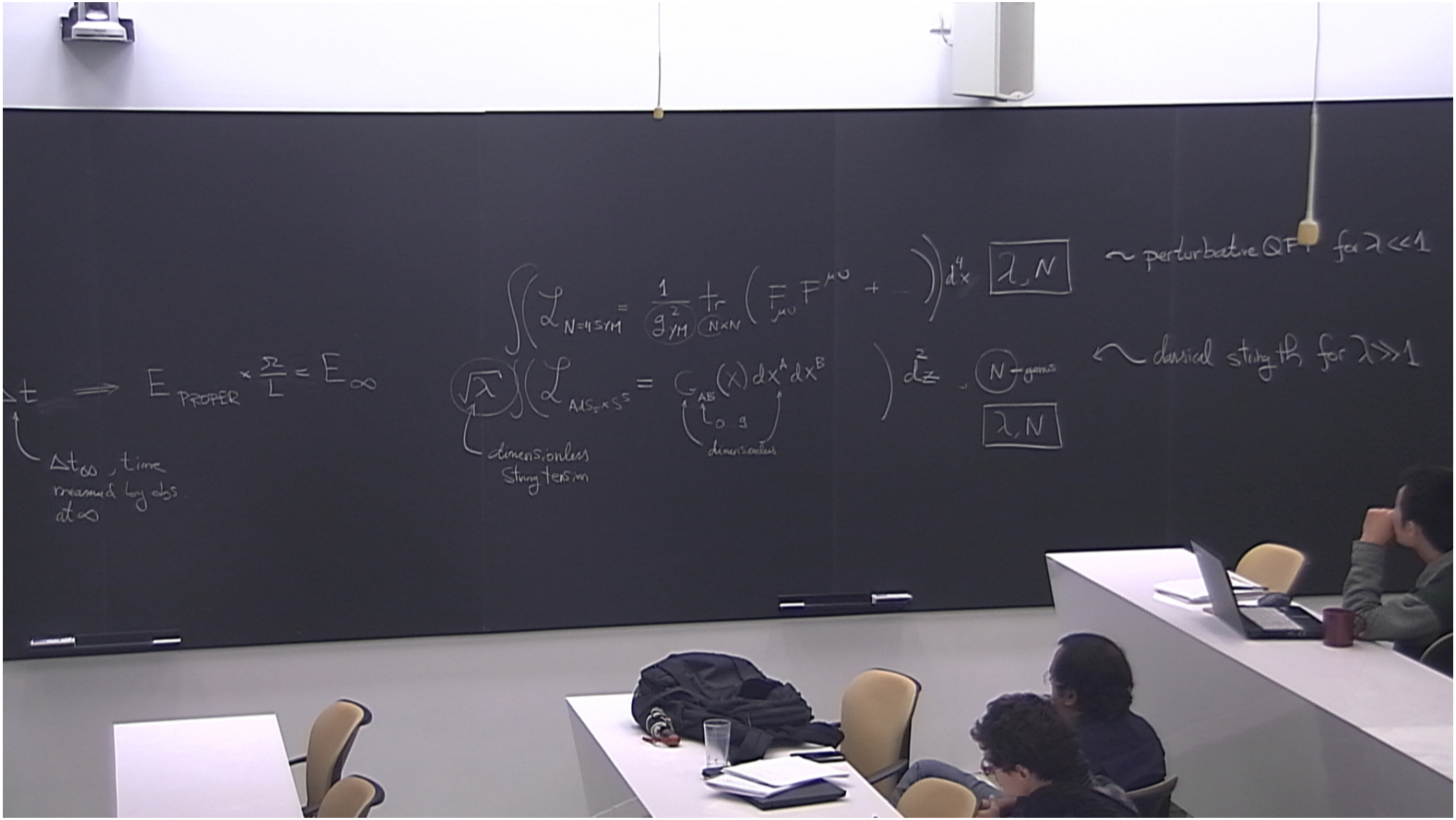

brane
bulk
brane
bulk
IIA
also dimensionful couplings
irrelevant op
10D SUGRA + higher derivative int
Low Energy limit of (A) =
N=4 Super Yang-Mills th in 3+1 dim
(+) free SUGRA in th
Low Energy limit of (B) =
Superstrings in AdS5 x S5
(+) free SUGRA

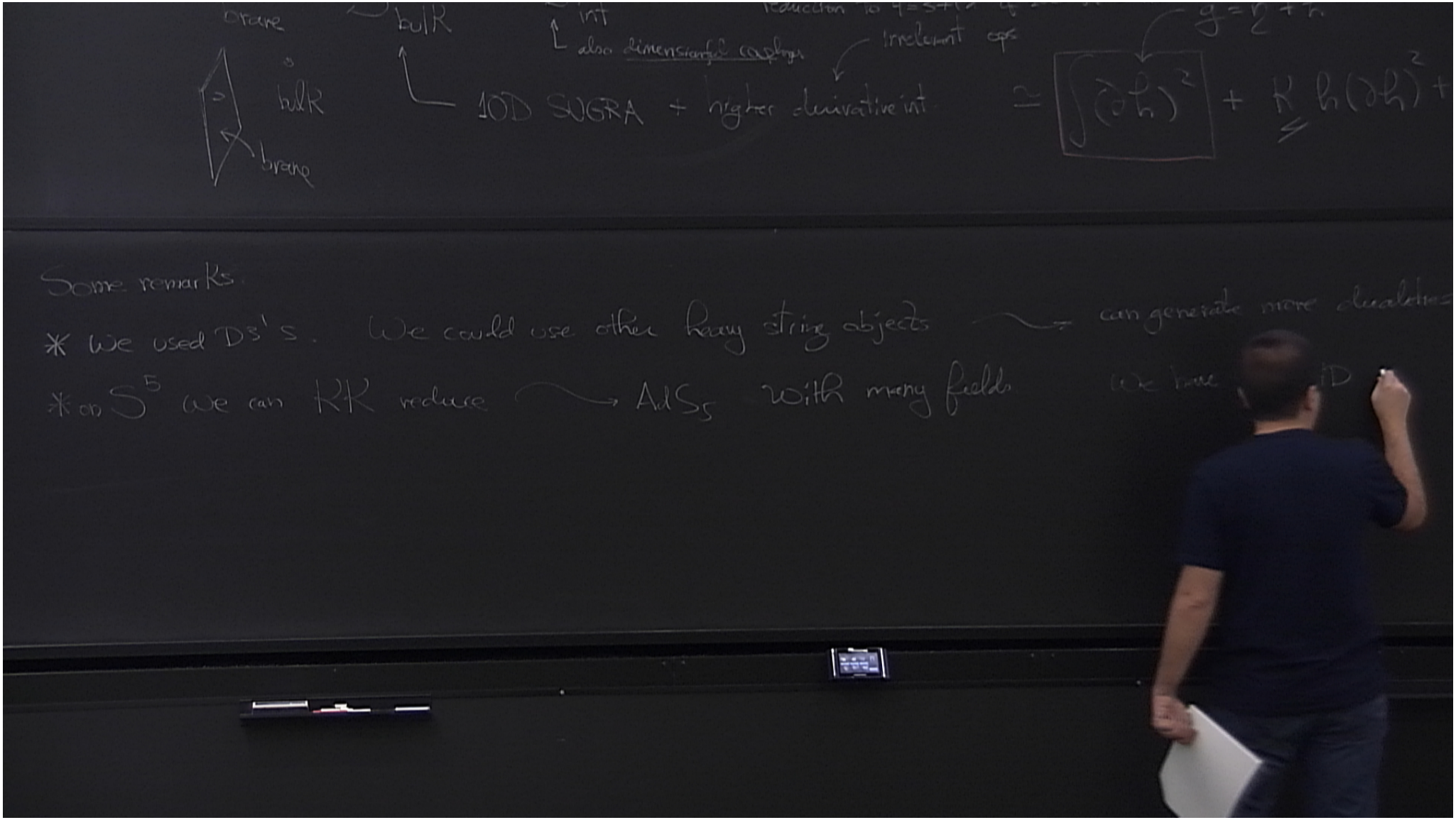

brane
bulk
brane
bulk
int
also dimensionful couplings
irrelevant ops
10D SUGRA + higher derivative int
Low Energy limit of (A) =
N=4 Super Yang-Mills th in 3+1 dim
free SUGRA in the bulk
Low Energy limit of (B) = '97 Maldacena
Superstrings in AdS5 x S5
free SUGRA

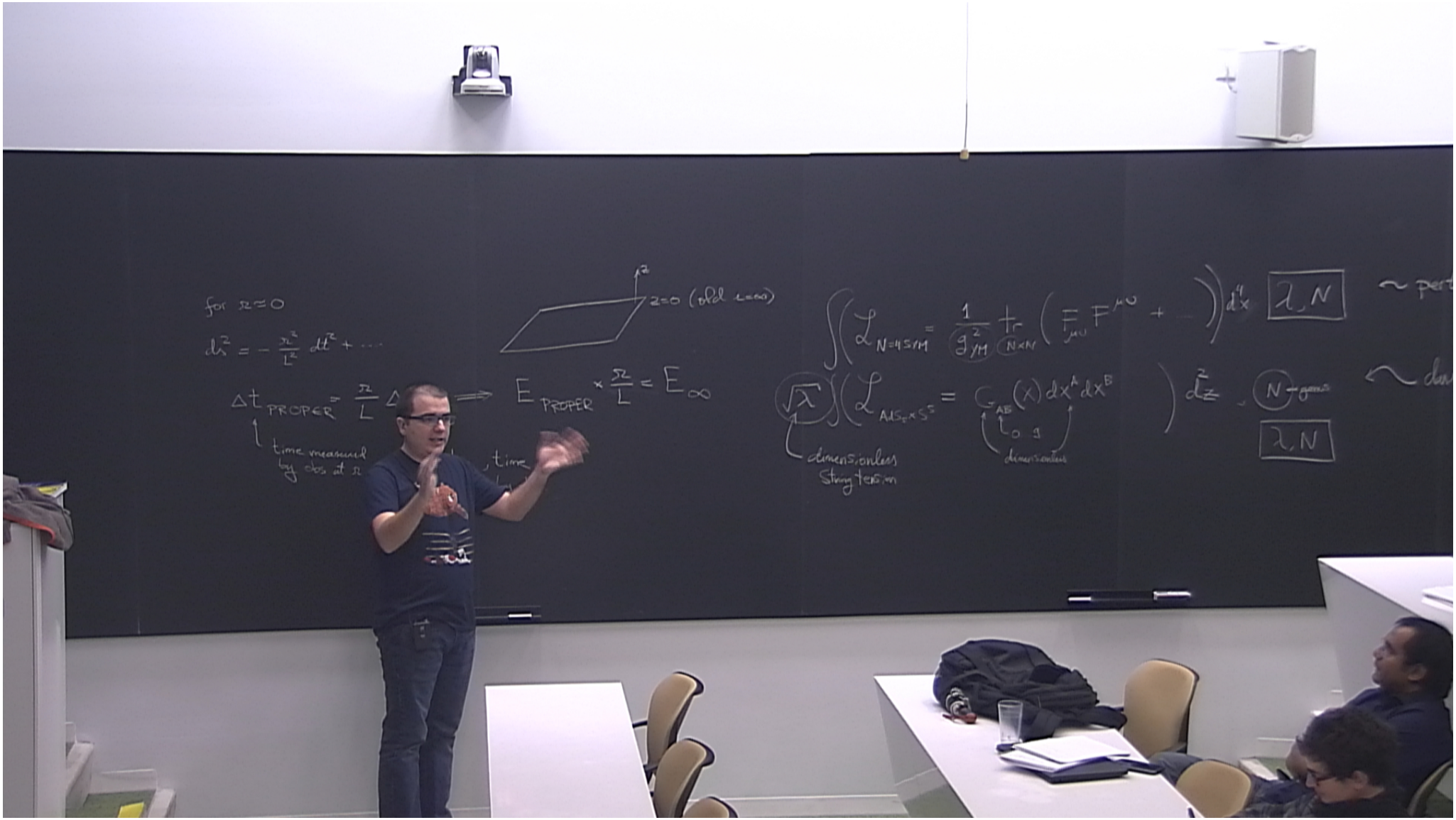

brane
bulk
brane
bulk
IR
also dimensionful couplings
irrelevant ops
10D SUGRA + higher derivative int
Low Energy limit of (A) =
N=4 Super Yang-Mills th in 3+1 dim
free SUGRA
Low Energy limit of (B) =
'97 Maldacena
AdS/CFT
Superstrings in AdS5 x S5
free SUGRA

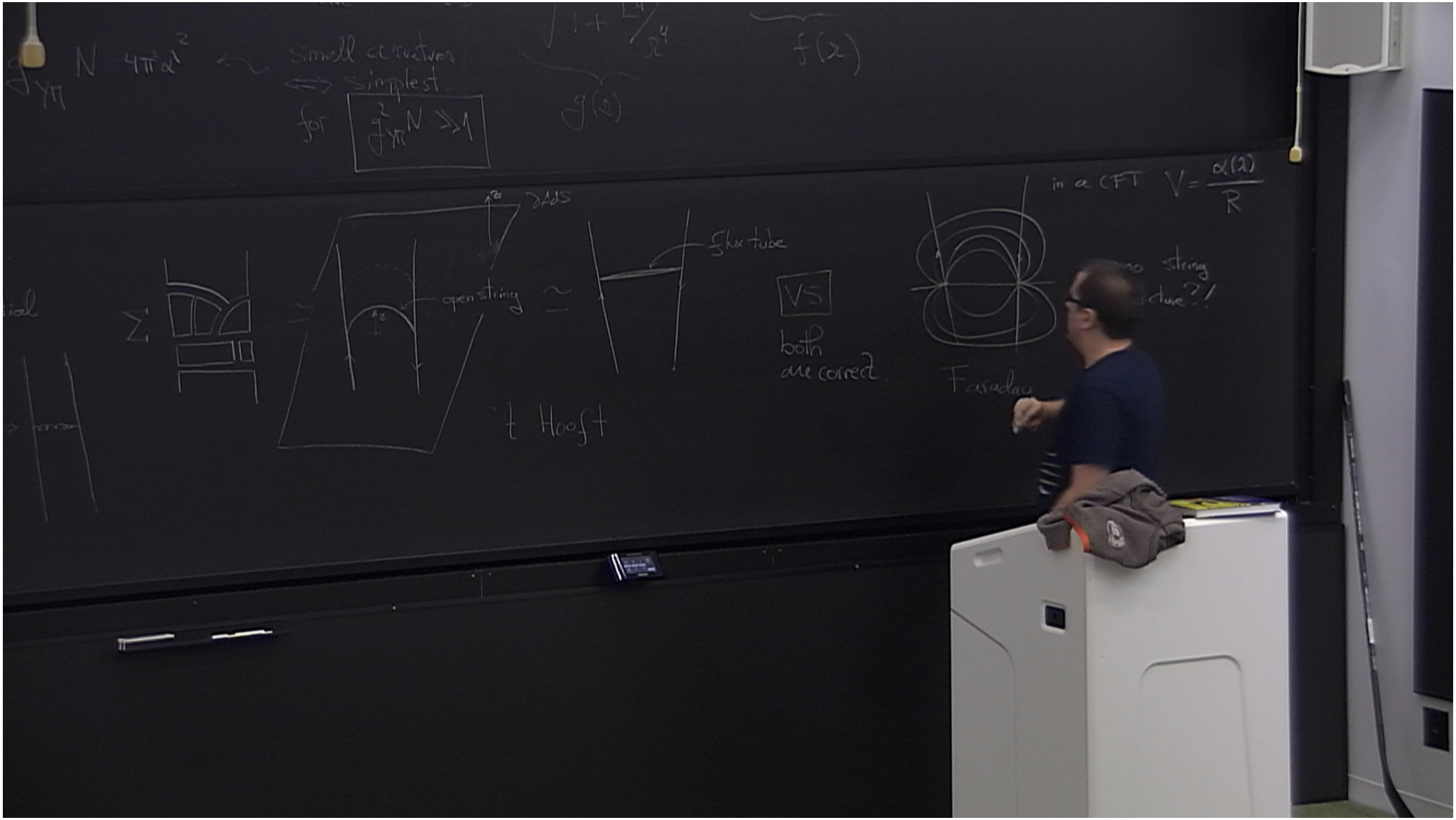

bulk
int
also dimensionful couplings
irrelevant ops
10D SUGRA + higher derivative int
$g = r^2 + h$
$\simeq \int (\partial h)^2 + \frac{K}{\Lambda} h (\partial h)^2 + \cdots$
useful (reliable) description if
$\lambda \equiv g_{YM}^2 N \ll 1$
free SUGRA in the bulk
Nest: we need
1) A Dictionary
'97 Maldacena
AdS/CFT
$AdS_5 \times S^5$

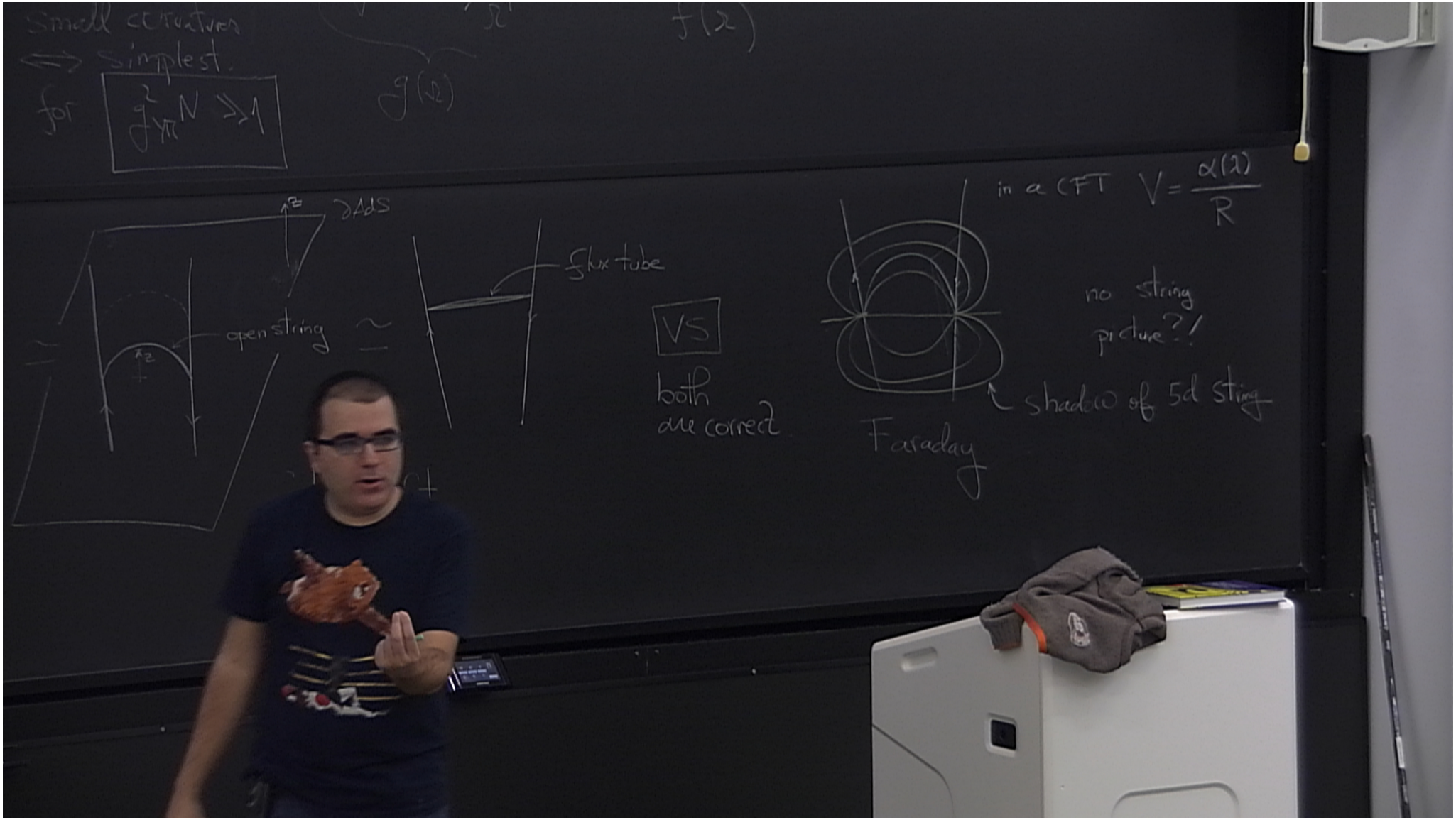

bulk
IR
int
also dimensionful couplings
reduction to d=3+1
irrelevant ops
g = n^2 + h
10D SUGRA + higher derivative int
≃ ∫(∂h)^2 + K/Λ h(∂h)^2 + ...
of (A) =
g-Mills th in 3+1 dim
⊕ free SUGRA in the bulk
useful (reliable) description if
λ ≡ g_YM^2 N ≪ 1
of (B) =
'97 Maldacena
AdS/CFT
AdS5 × S5
⊕ free SUGRA
Net: we need
1) A Dictionary
2) Checks

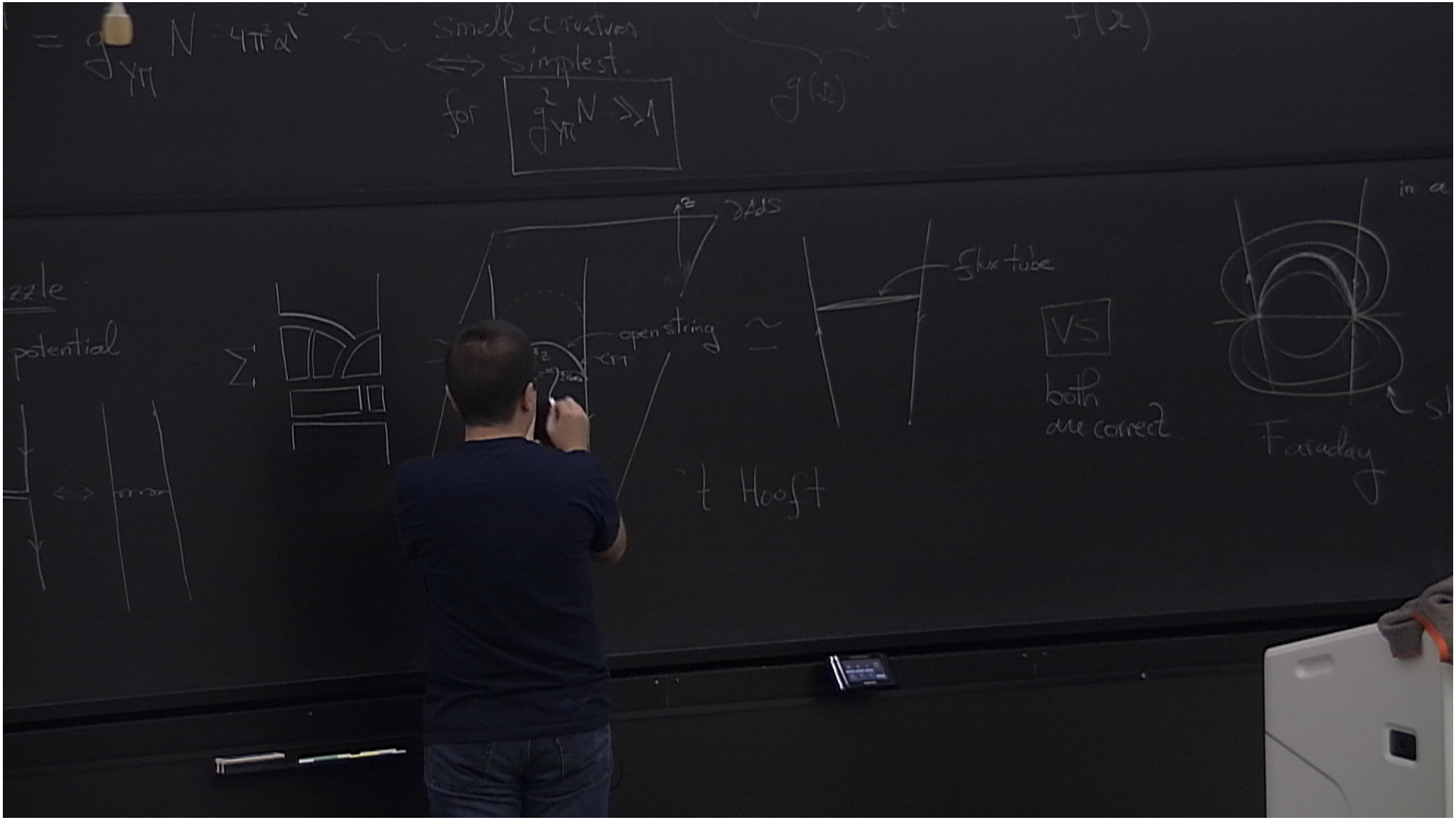

$\mathcal{L}_{N=4\,SYM} = \frac{1}{g^2_{YM}} \mathrm{tr}_{N\times N}\left(F_{\mu\nu}F^{\mu\nu} + \dots\right)d^4x$
$\lambda, N$
$\sim$ perturbative QFT for $\lambda \ll 1$
$\sqrt{\lambda}\left(\mathcal{L}_{AdS_5\times S^5} = G_{AB}(X)\,dx^A dx^B\right)d^2z$
$N \to \infty$
$\lambda, N$
$\sim$ classical string th. for $\lambda \gg 1$
$\Delta t \Longrightarrow E_{PROPER} \times \frac{\Sigma z}{L} = E_\infty$
$\Delta t_\infty$, time measured by obs at $\infty$
dimensionless String tension
dimensionless
$l_0$ $g$


brane
bulk
brane
bulk
10D SUGRA + higher derivative int
also dimensionful couplings
irrelevant ops
Some remarks
* We used D3's. We could use other heavy string objects
* on $S^5$ we can KK reduce $AdS_5$ with many fields


for z=0
$ds^2 = -\frac{z^2}{L^2}dt^2 + \cdots$
$\Delta t_{PROPER} = \frac{z}{L}\Delta$
time measured by obs at z
$\Rightarrow E_{PROPER} \times \frac{z}{L} < E_\infty$
z=0 (bdd ∀ z→∞)
$\int(\mathcal{L}_{N=4\,SYM} = \frac{1}{g^2_{YM}} \mathrm{tr}_{N\times N}(F_{\mu\nu}F^{\mu\nu} + \cdots))d^4x$
λ, N
$\sqrt{\lambda}(\mathcal{L}_{AdS_5\times S^5} = G_{AB}(x)dx^A dx^B)d^5z$
dimensionless String tension
dimensionful
N → ∞
λ, N


small curvatures
simplest
for
AdS
open string
flux tube
VS
both
are correct
't Hooft
in a CFT
Faraday


small curvature
⇔ simplest
for $\frac{g^2}{4\pi} N \gg 1$
$f(x)$
$g(x_2)$
$x^2$
AdS
open string
flux tube
VS
both
are correct
in a CFT $V = \frac{\alpha(x)}{R}$
no string
picture?!
shadow of 5d string
Faraday


small curvatures
⇔ simplest.
for $g^2_{YM} N \gg 1$
AdS
open string
flux tube
VS
both
are correct
't Hooft
Faraday