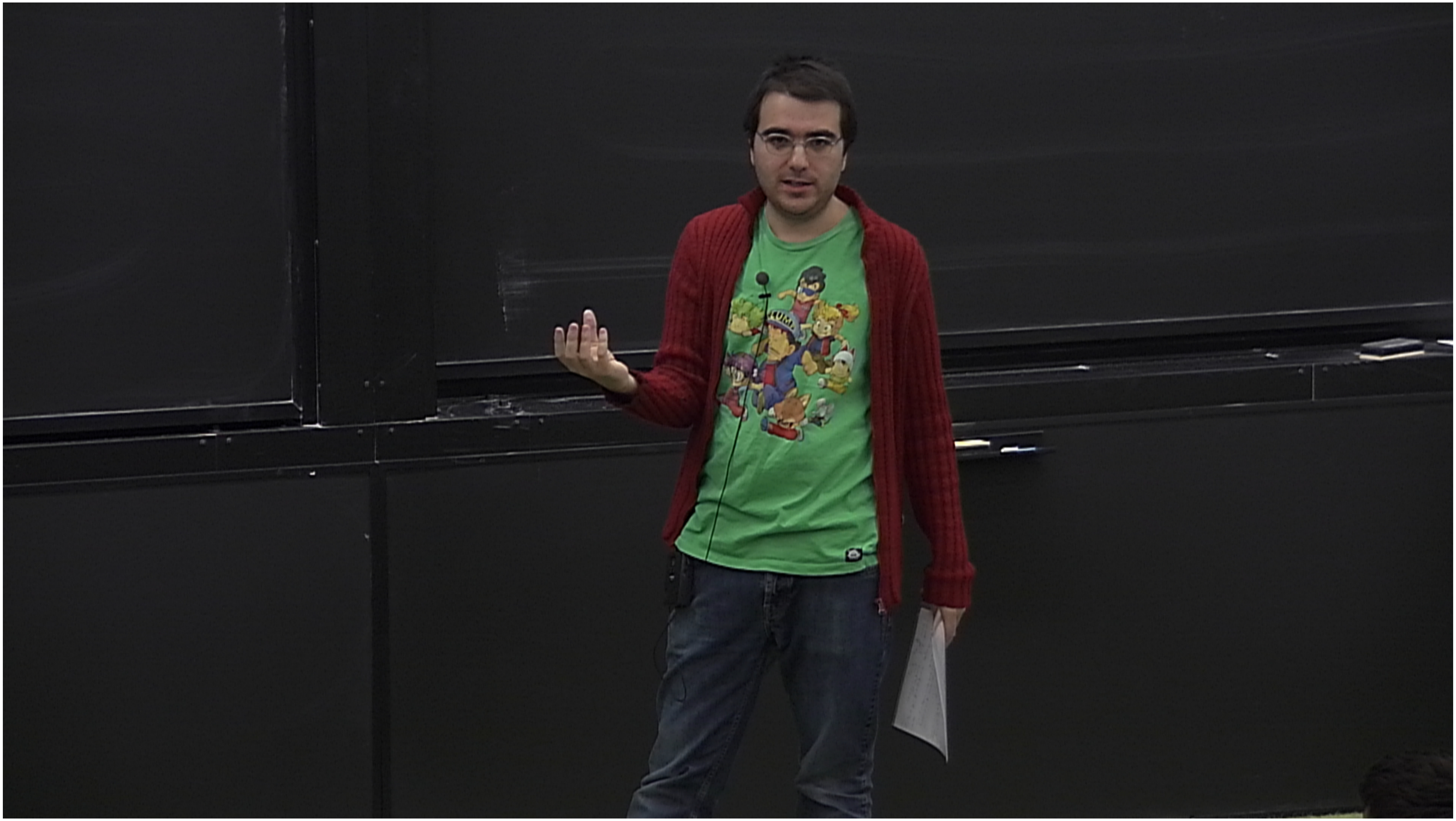
Title: Explorations in String Theory - Lecture 3

Date: Mar 14, 2012 11:30 AM

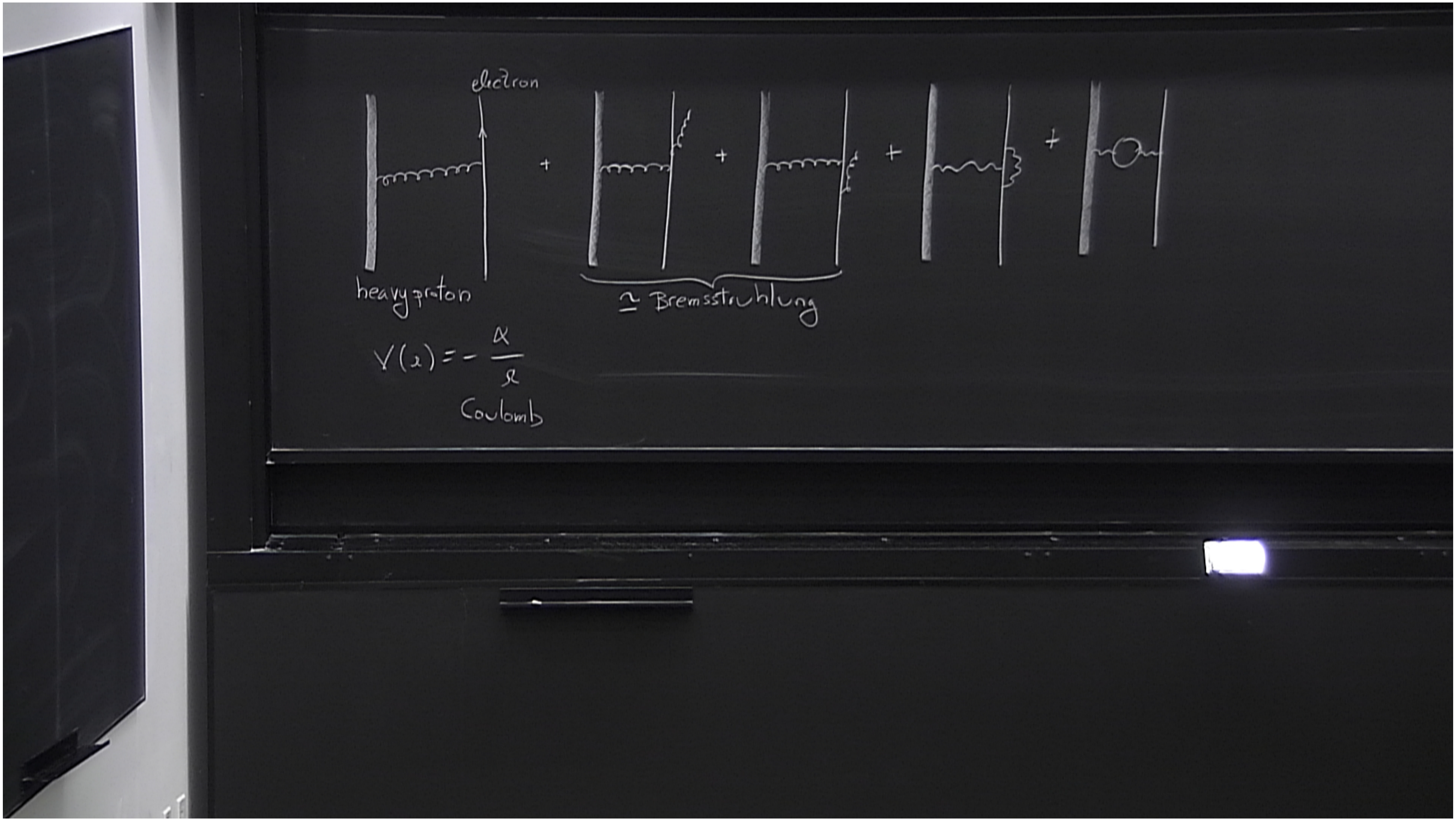
URL: http://pirsa.org/12030044

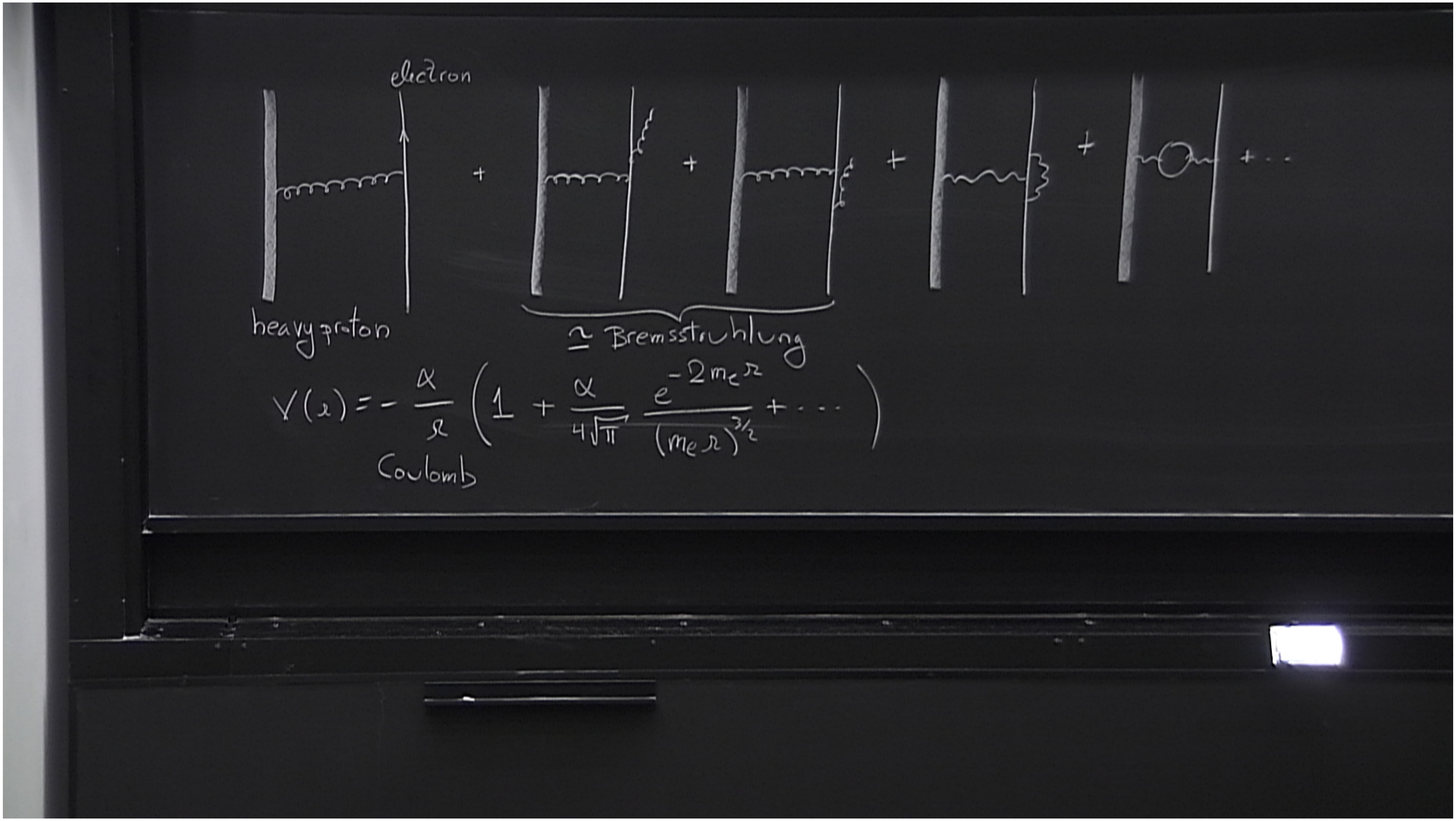
Abstract:

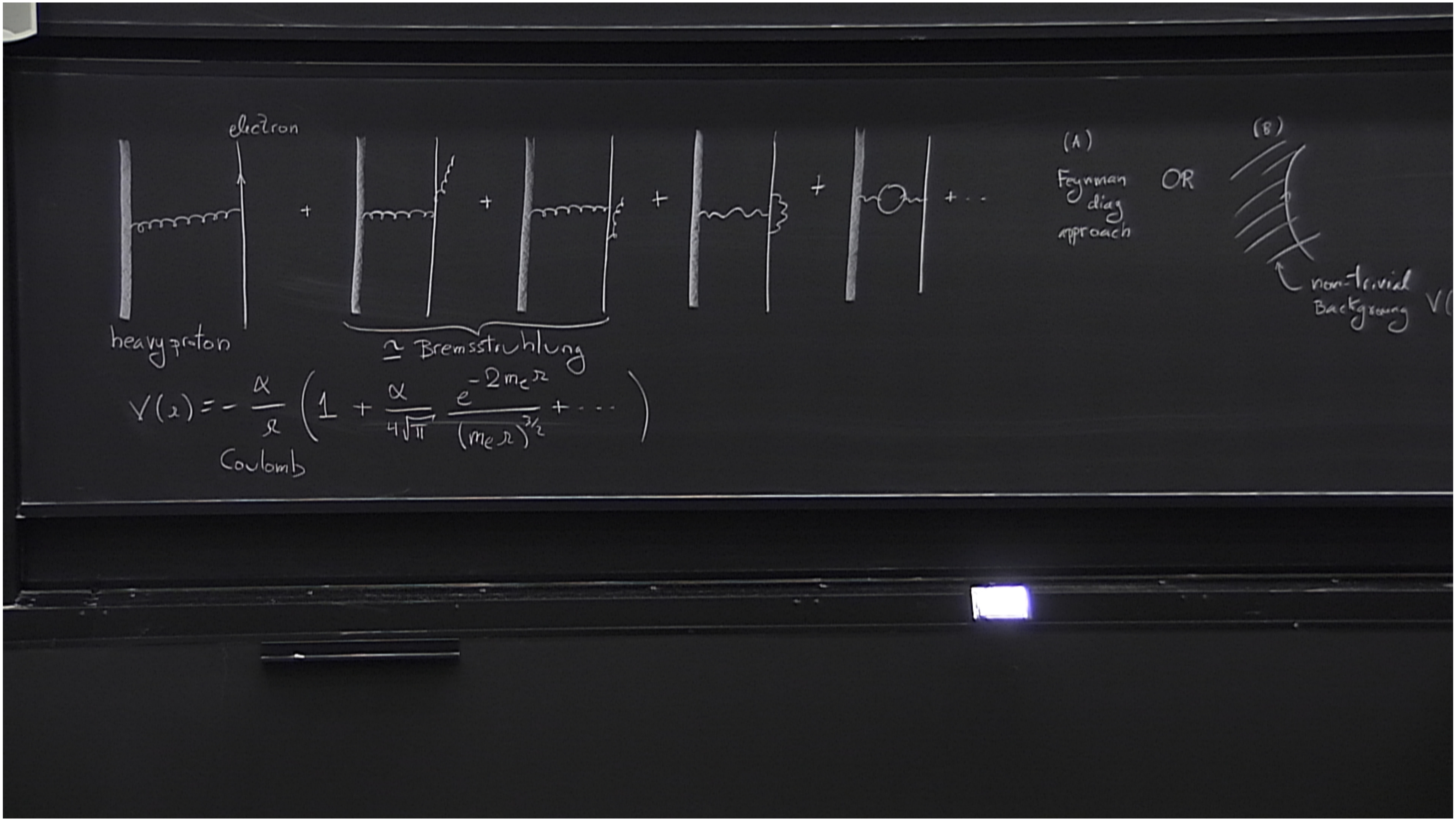


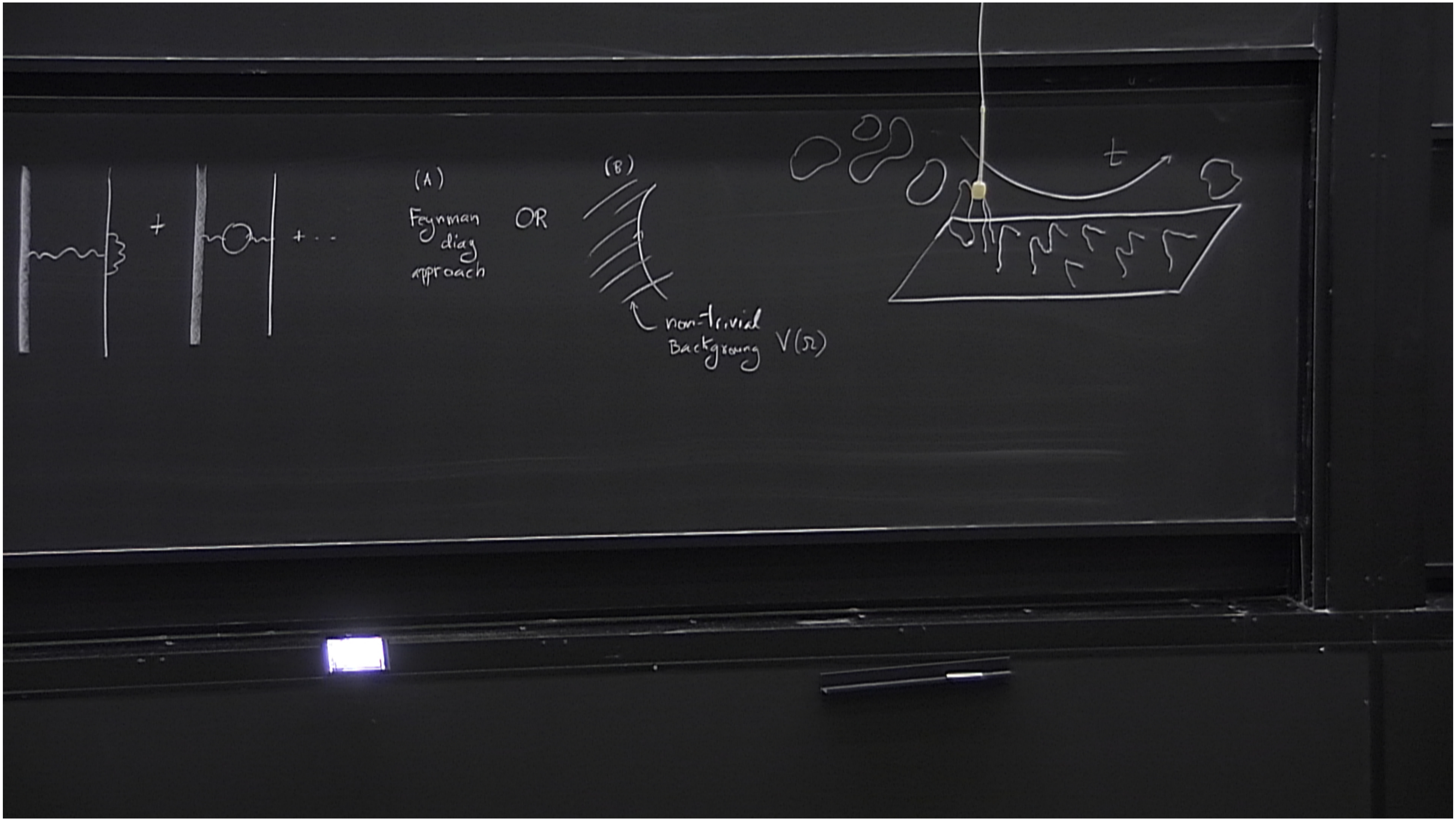
... we are therefore lead to conjecture that

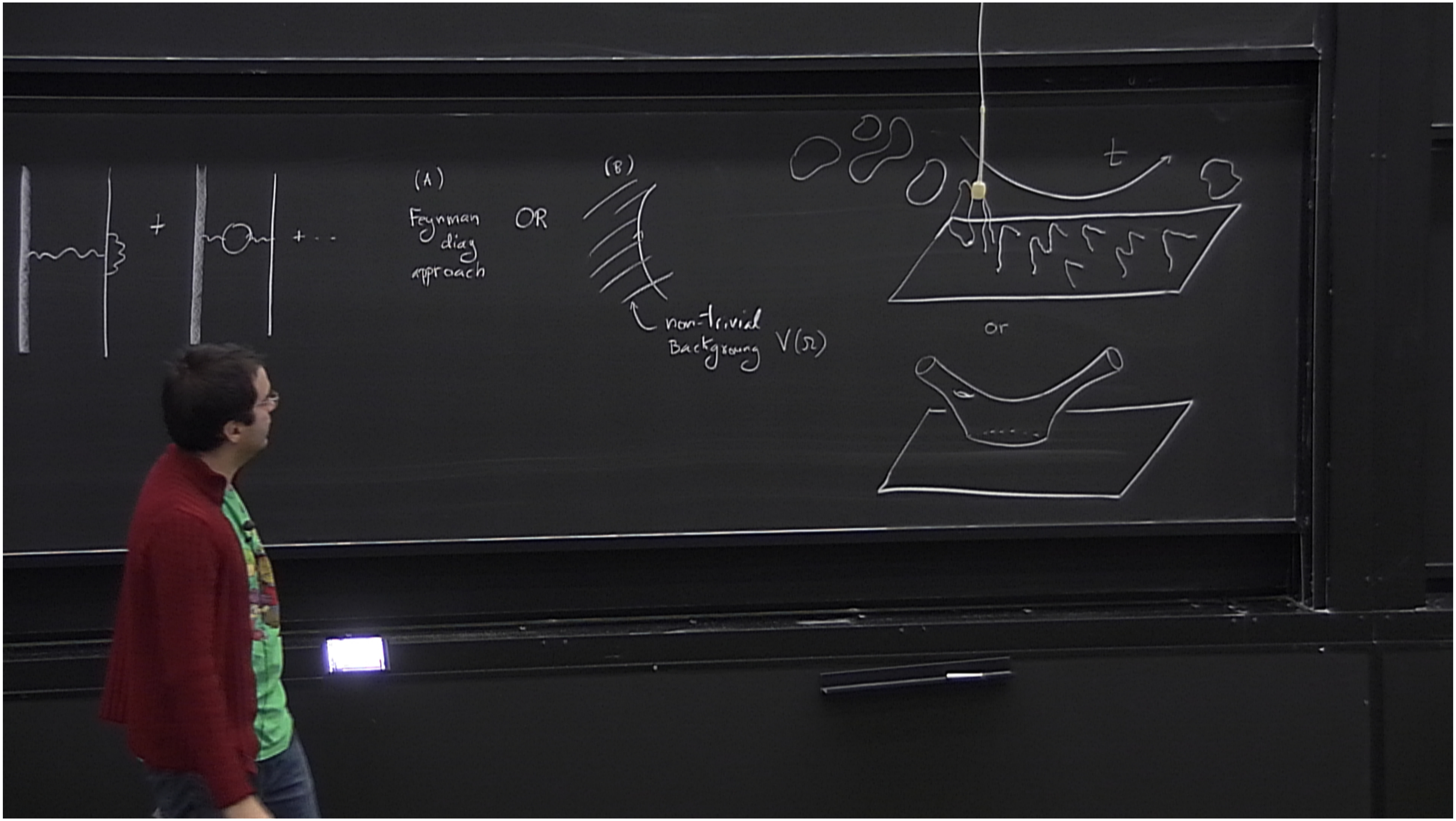
$$\boxed{4D,\ \mathcal{N}=4\ \text{SYM} = \text{type IIB strings in } AdS_5 \times S^5}$$

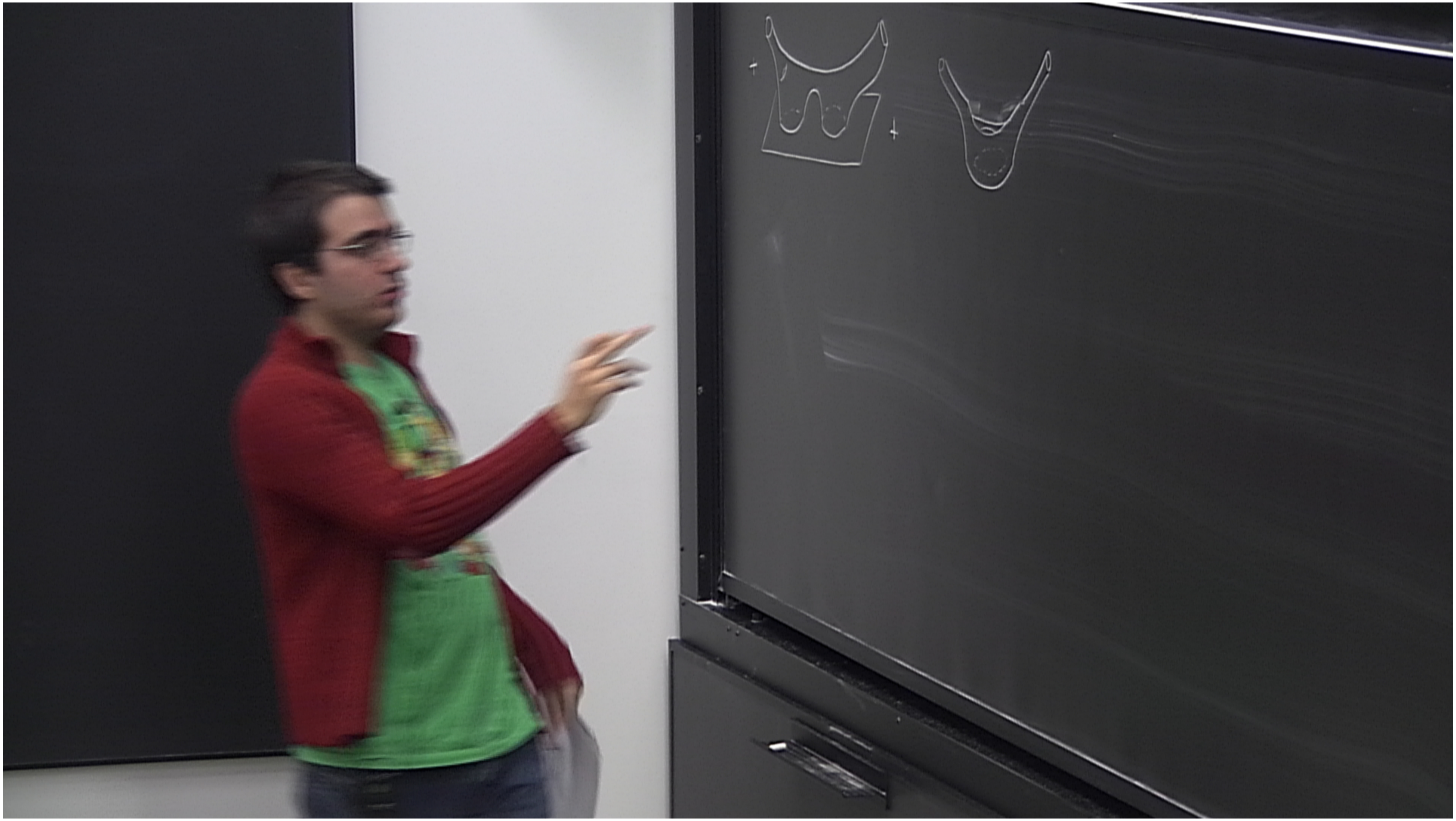

electron
heavy proton
≃ Bremsstrahlung
$V(r) = -\frac{\alpha}{r}$
Coulomb

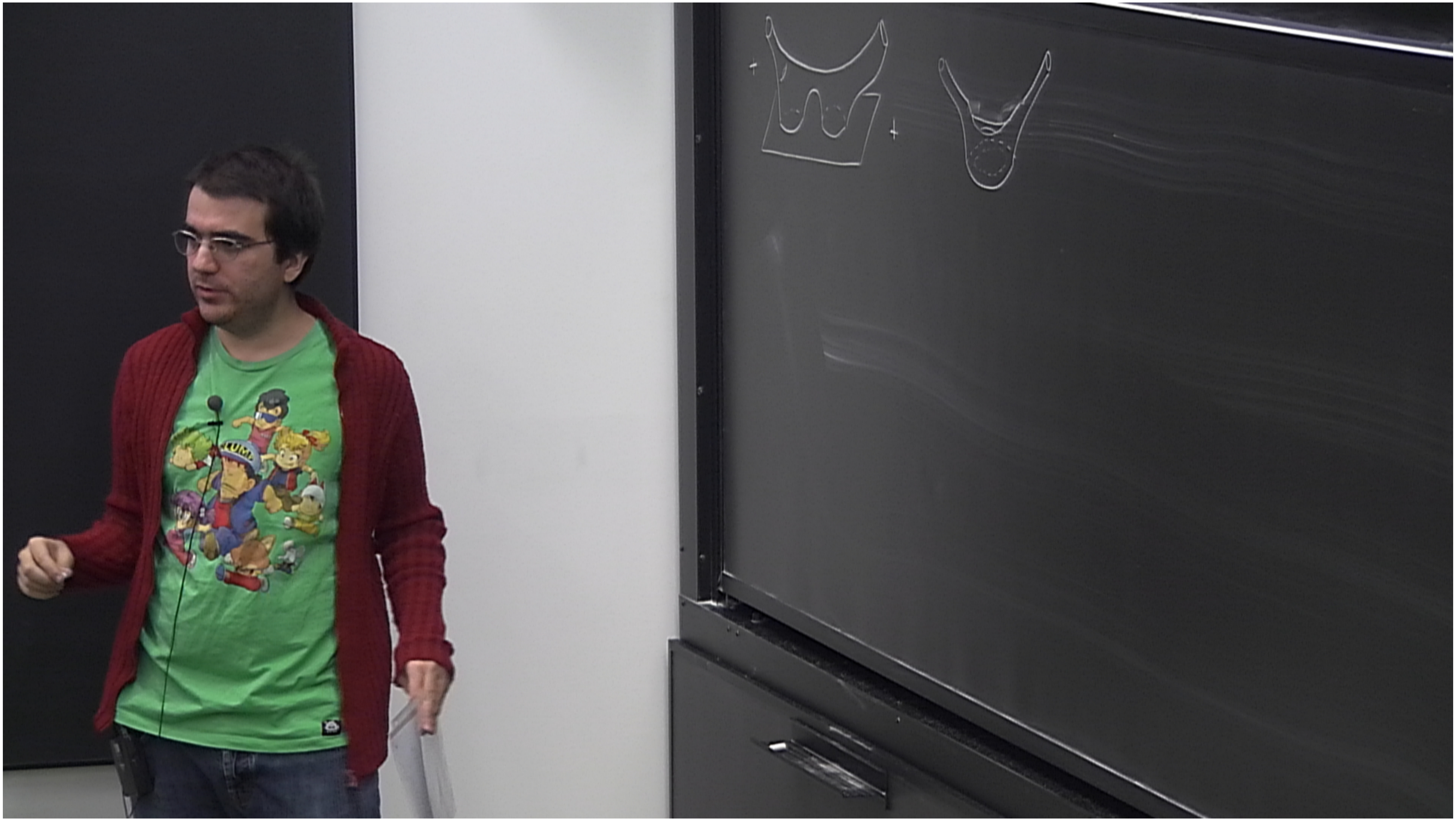

electron
heavy proton
$\simeq$ Bremsstrahlung
$V(r) = -\frac{\alpha}{r}\left(1 + \frac{\alpha}{4\sqrt{\pi}}\frac{e^{-2m_e r}}{(m_e r)^{3/2}} + \cdots\right)$
Coulomb

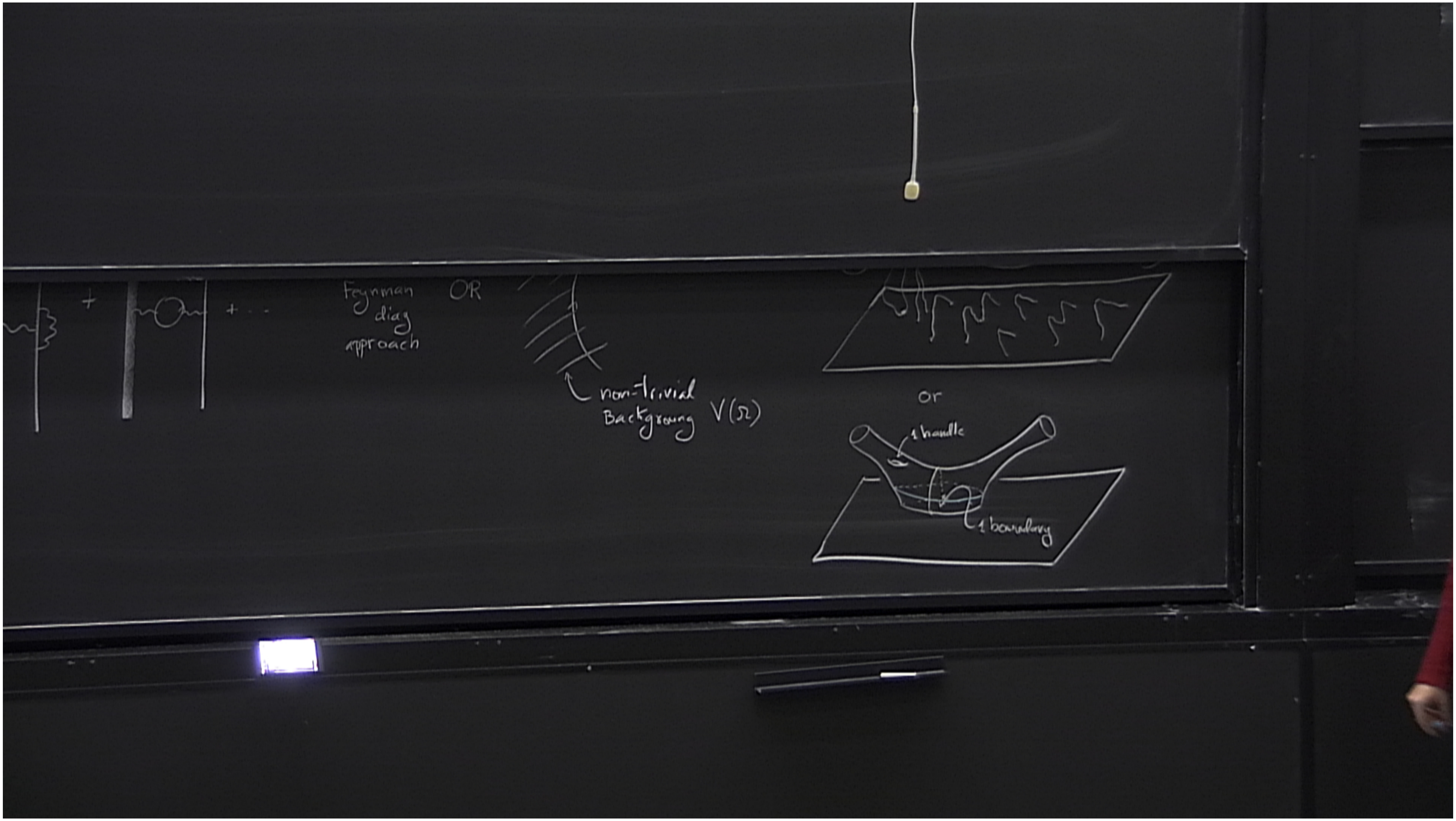

electron
heavy proton
+
+
+
+
+ . . .
≃ Bremsstrahlung
(A)
Feynman diag approach
OR
(B)
non-trivial Background V(
$V(r) = -\frac{\alpha}{r}\left(1 + \frac{\alpha}{4\sqrt{\pi}} \frac{e^{-2m_e r}}{(m_e r)^{3/2}} + \cdots\right)$
Coulomb

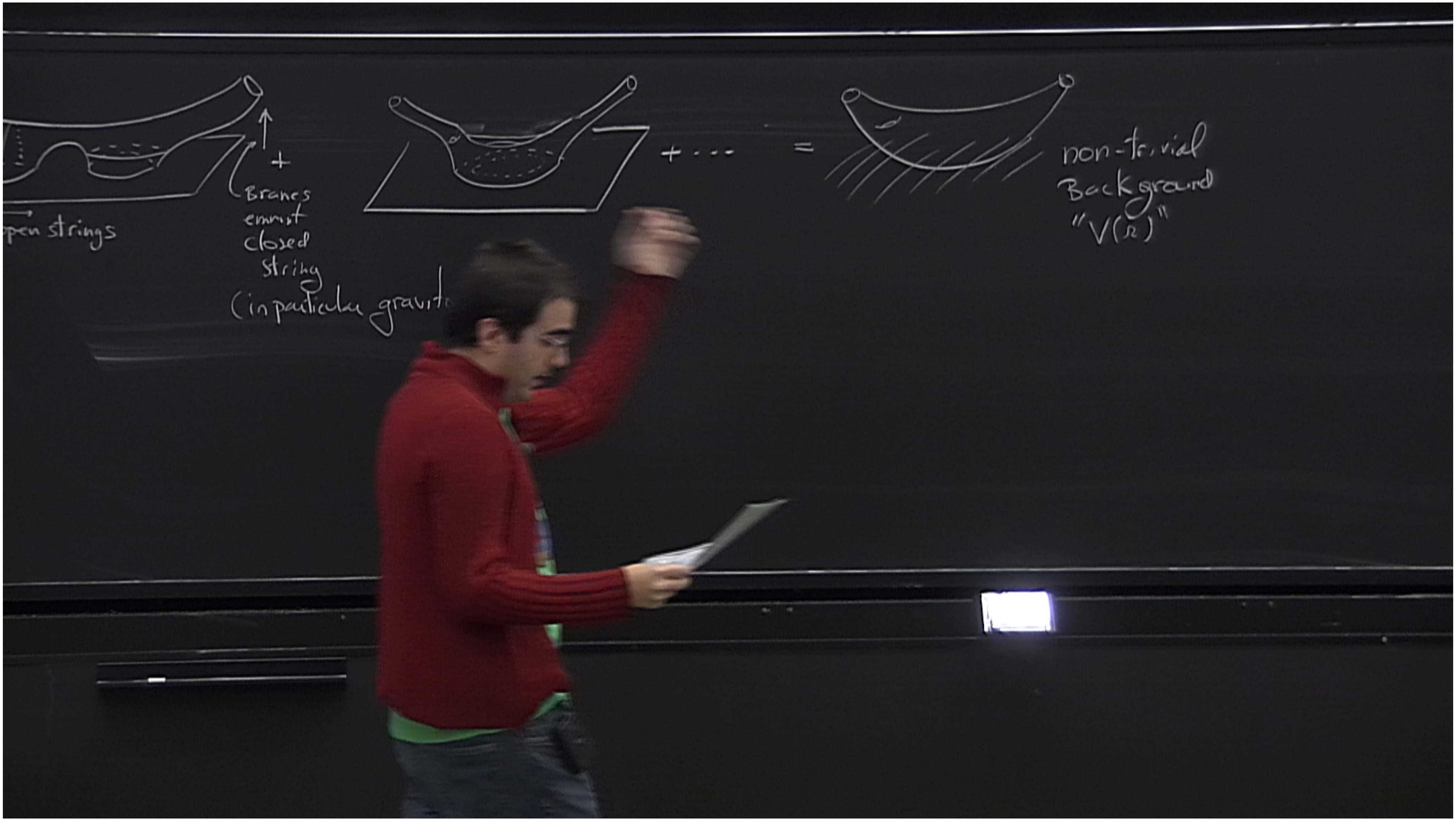

+
+ . . .
(A)
Feynman diag approach
OR
(B)
non-trivial Background V(Ω)
t


(A)
Feynman diag approach
OR
(B)
non-trivial Background V(Ω)
t
or

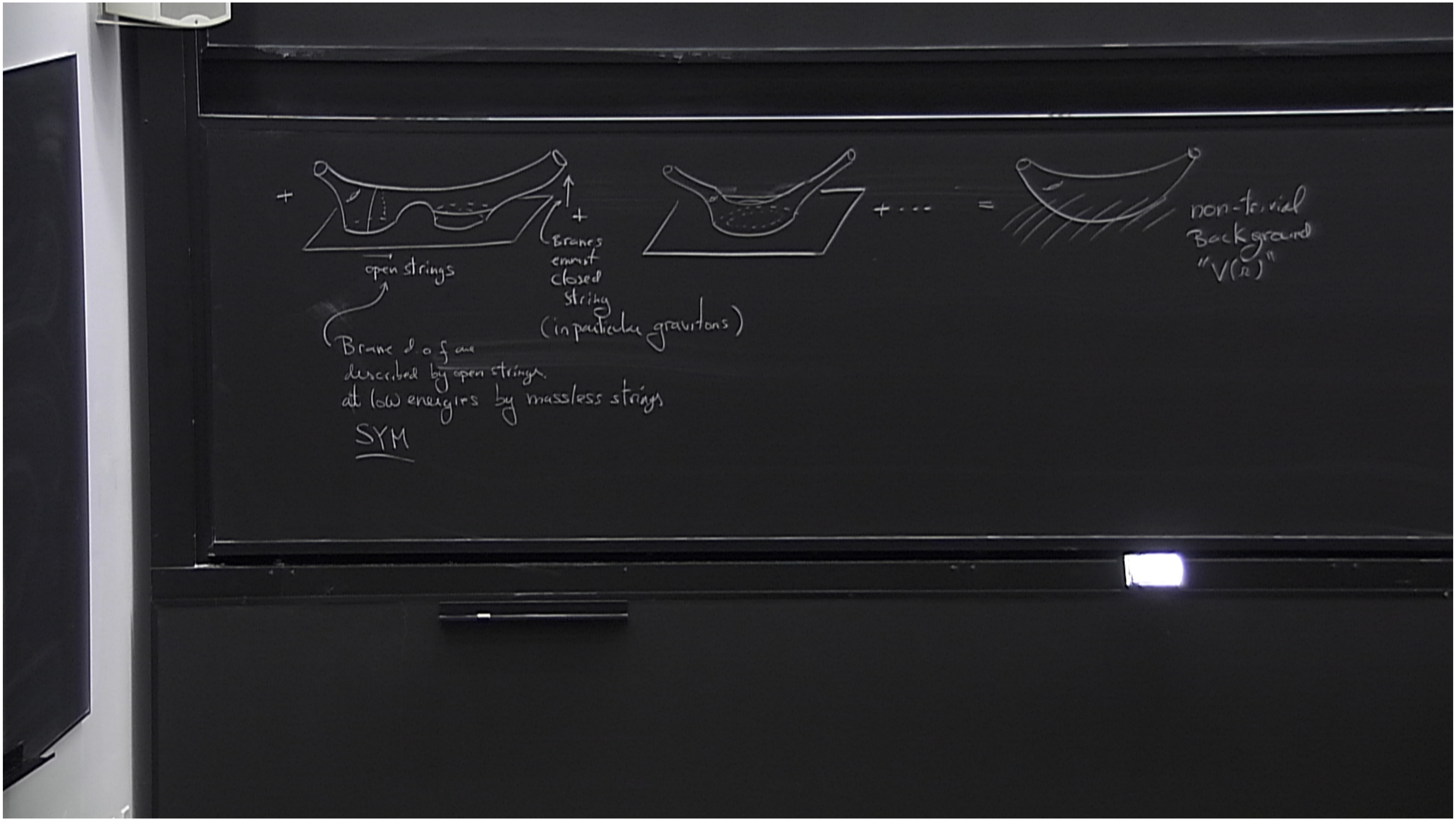




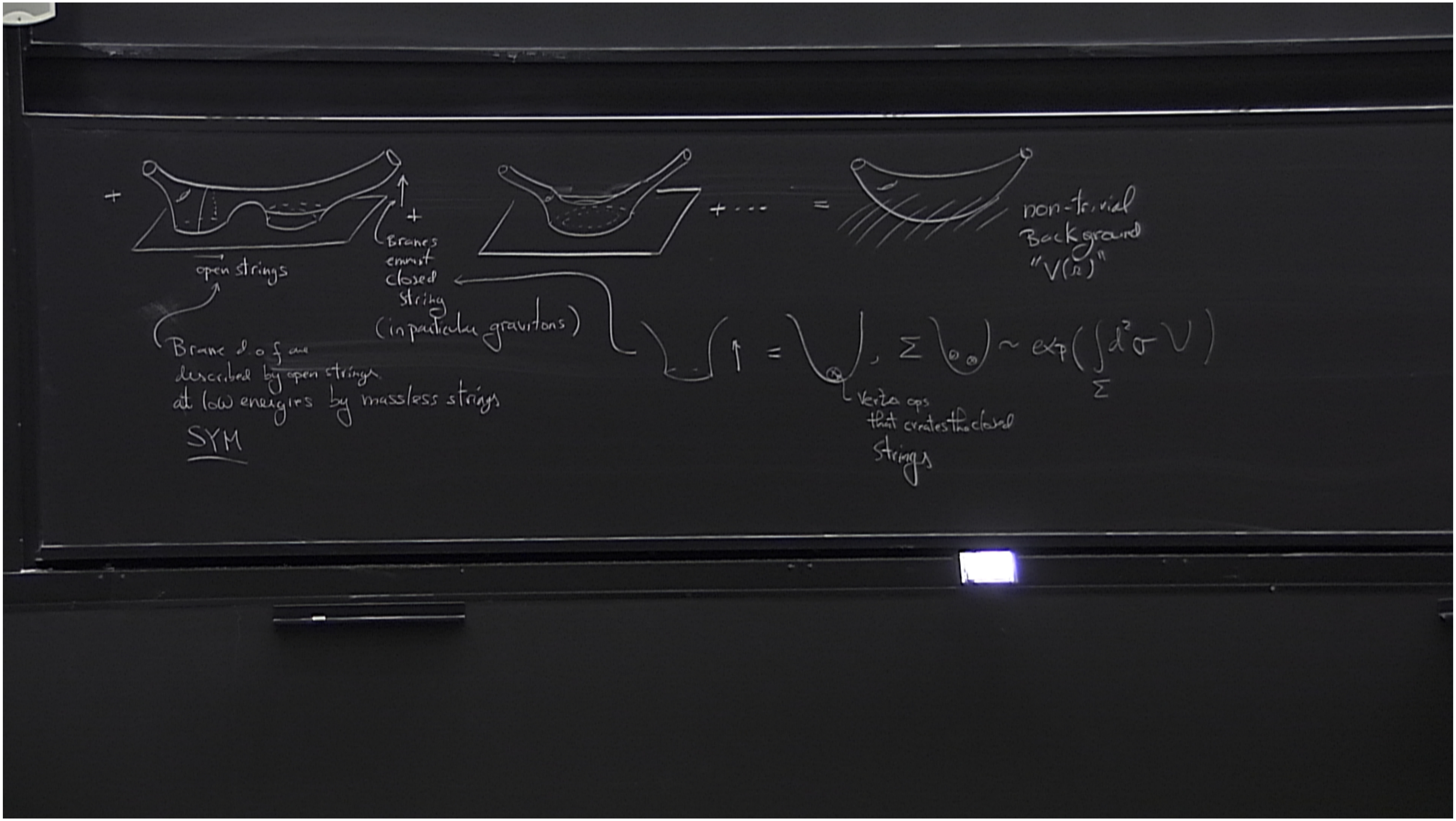

Feynman diag approach
OR
non-trivial Background $V(\Omega)$
or
1 handle
1 boundary

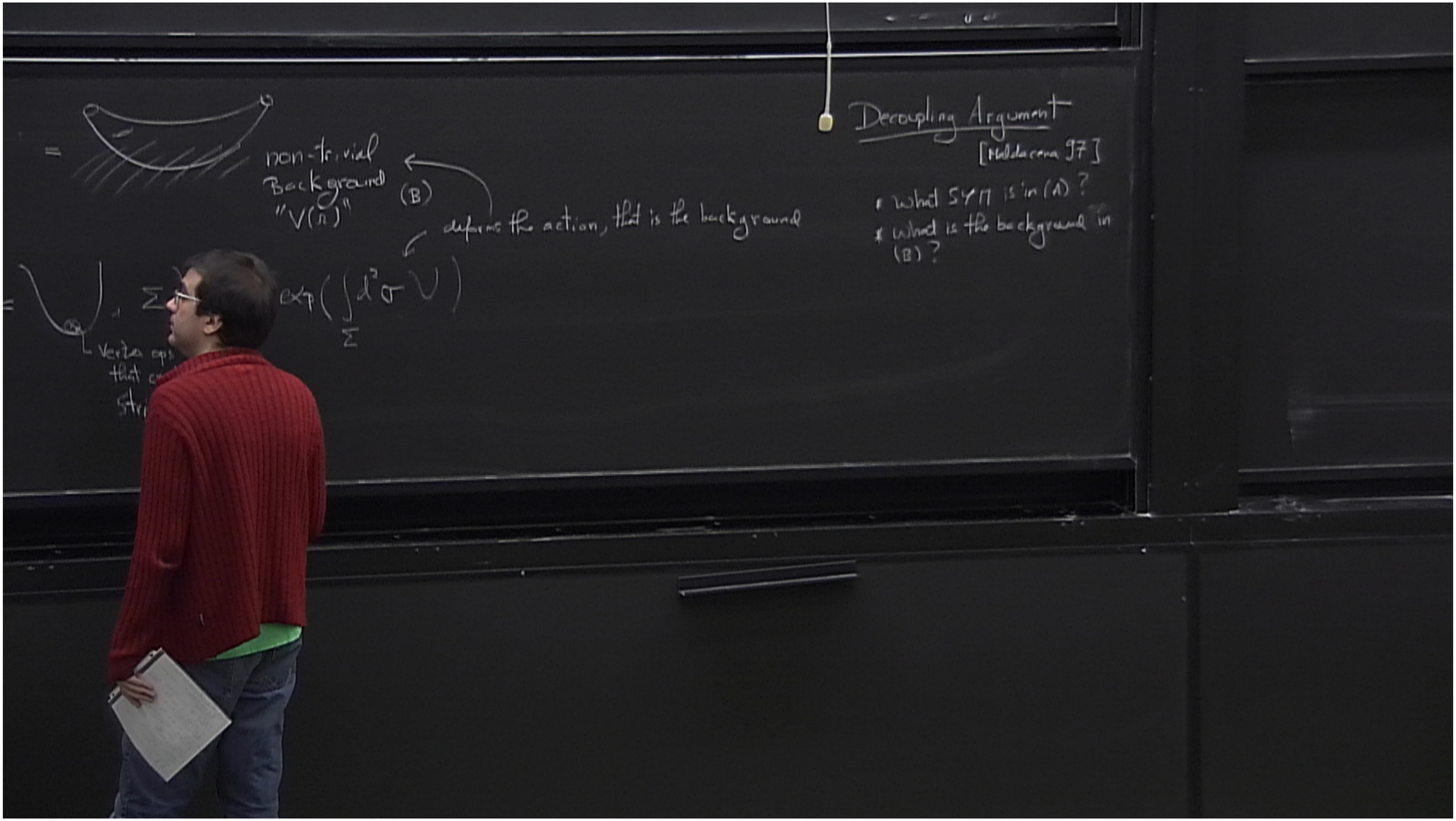


open strings
Branes emmit closed string
(in particular gravit
non-trivial Background
"V(Ω)"



+
open strings
+
Branes
emmit
closed
string
(in particular gravitons)
Brane d.o.f are
described by open strings
at low energies by massless strings
SYM
+ . . .
=
non-trivial
Background
"V(Ω)"


open strings
Branes emmit closed string
(in particular gravitons)
Brane d.o.f are described by open strings
at low energies by massless strings
SYM
non-trivial Background
"V(Ω)"
Vertex ops that creates the closed strings
~ exp(∫_Σ d²σ V)

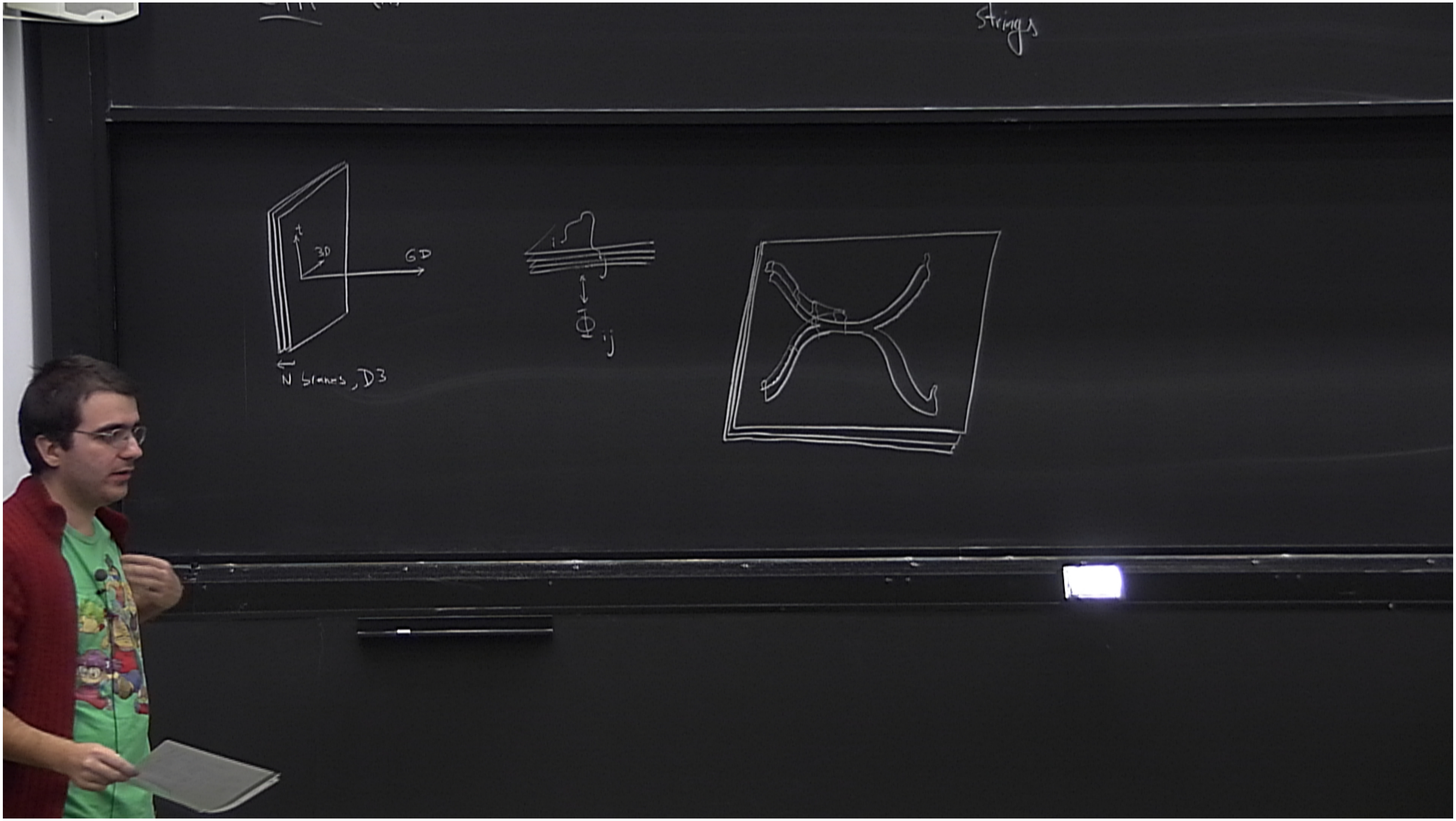

non-trivial
Background
"V(Ω)"
(B)
deforms the action, that is the background
exp(∫ d²σ V)
Σ
Vertex ops
Decoupling Argument
[Maldacena 97]
* What SYM is in (A) ?
* What is the background in (B) ?

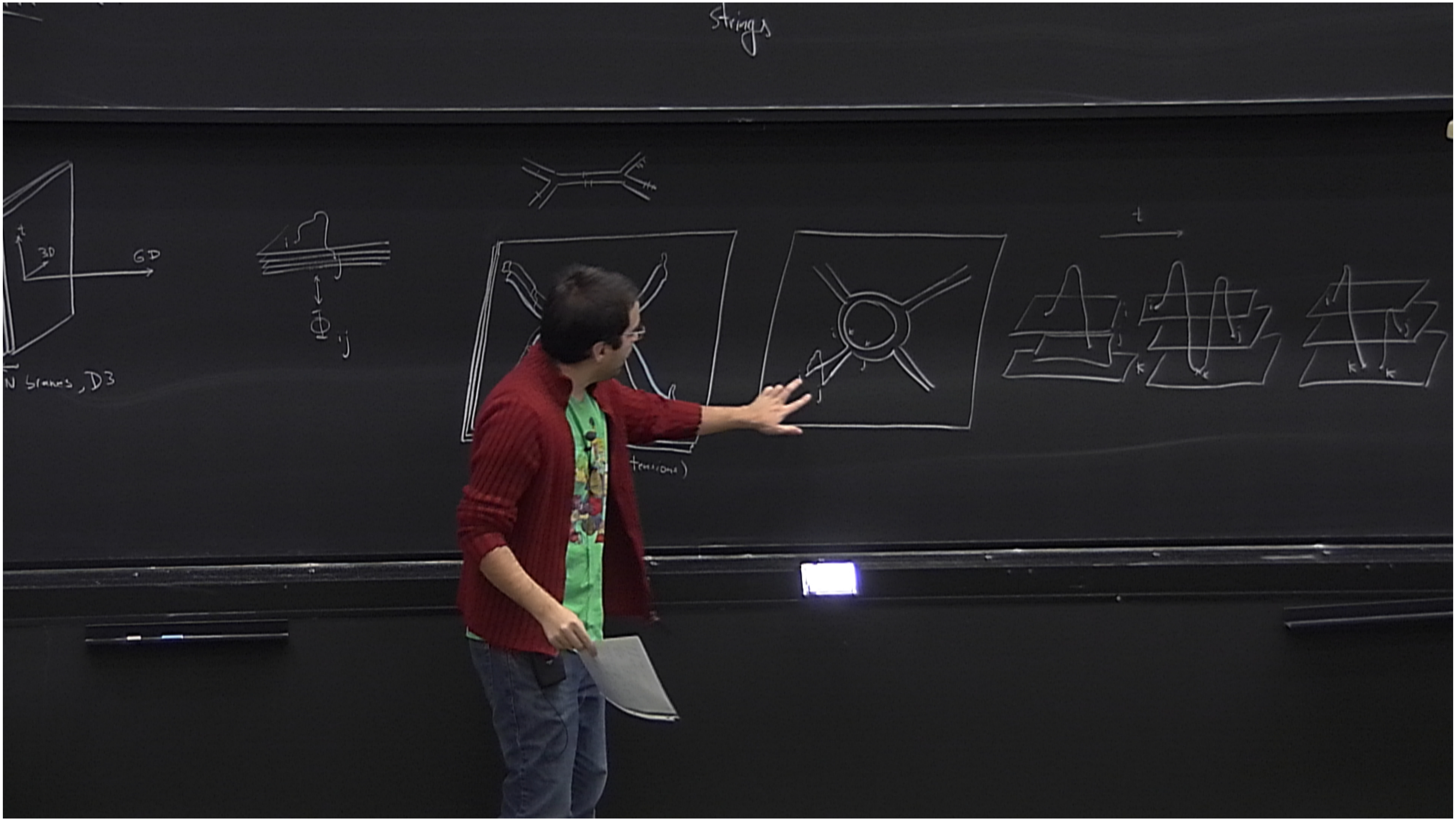
action, that is the background

Decoupling Argument

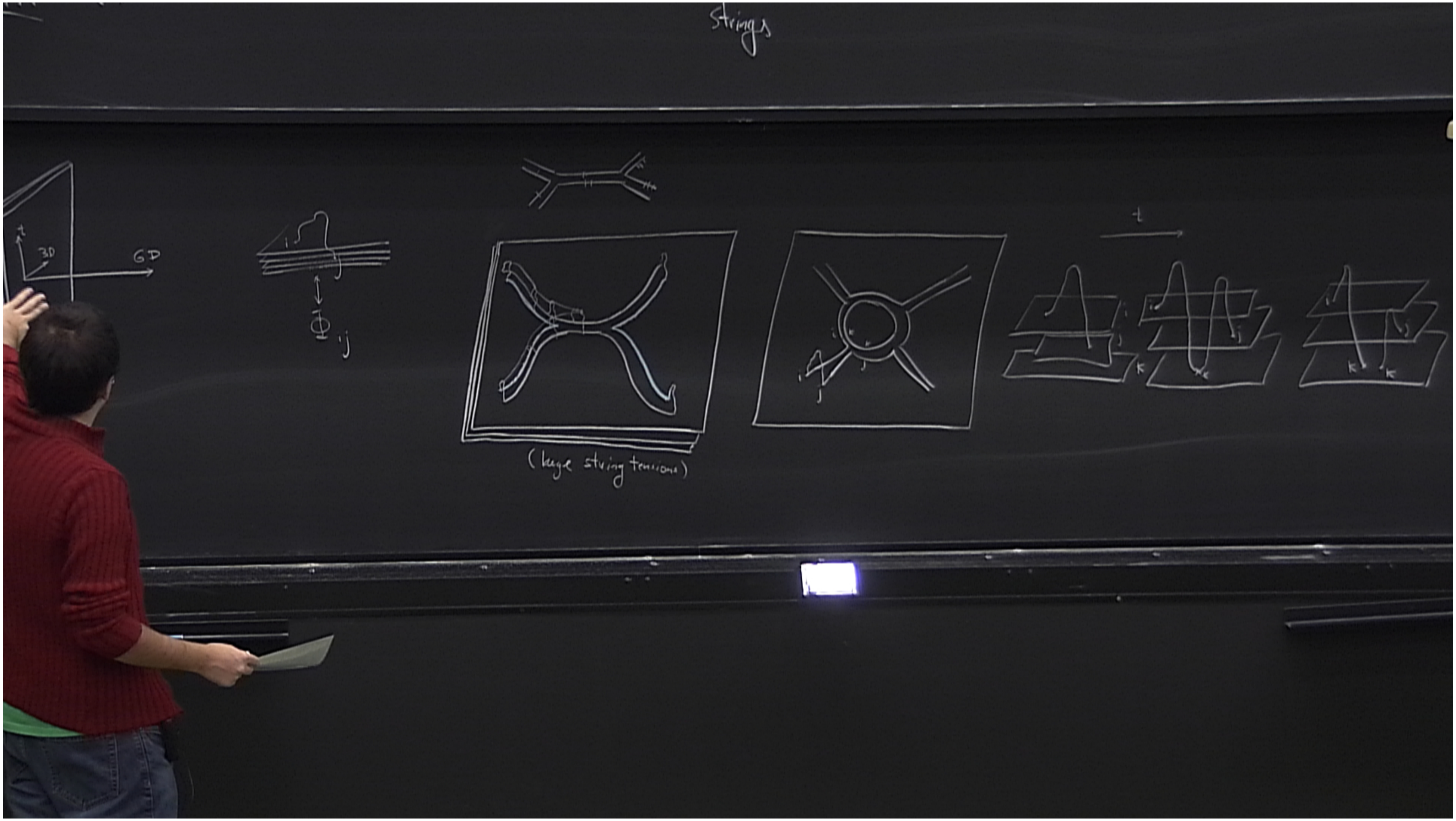
[Maldacena 97]

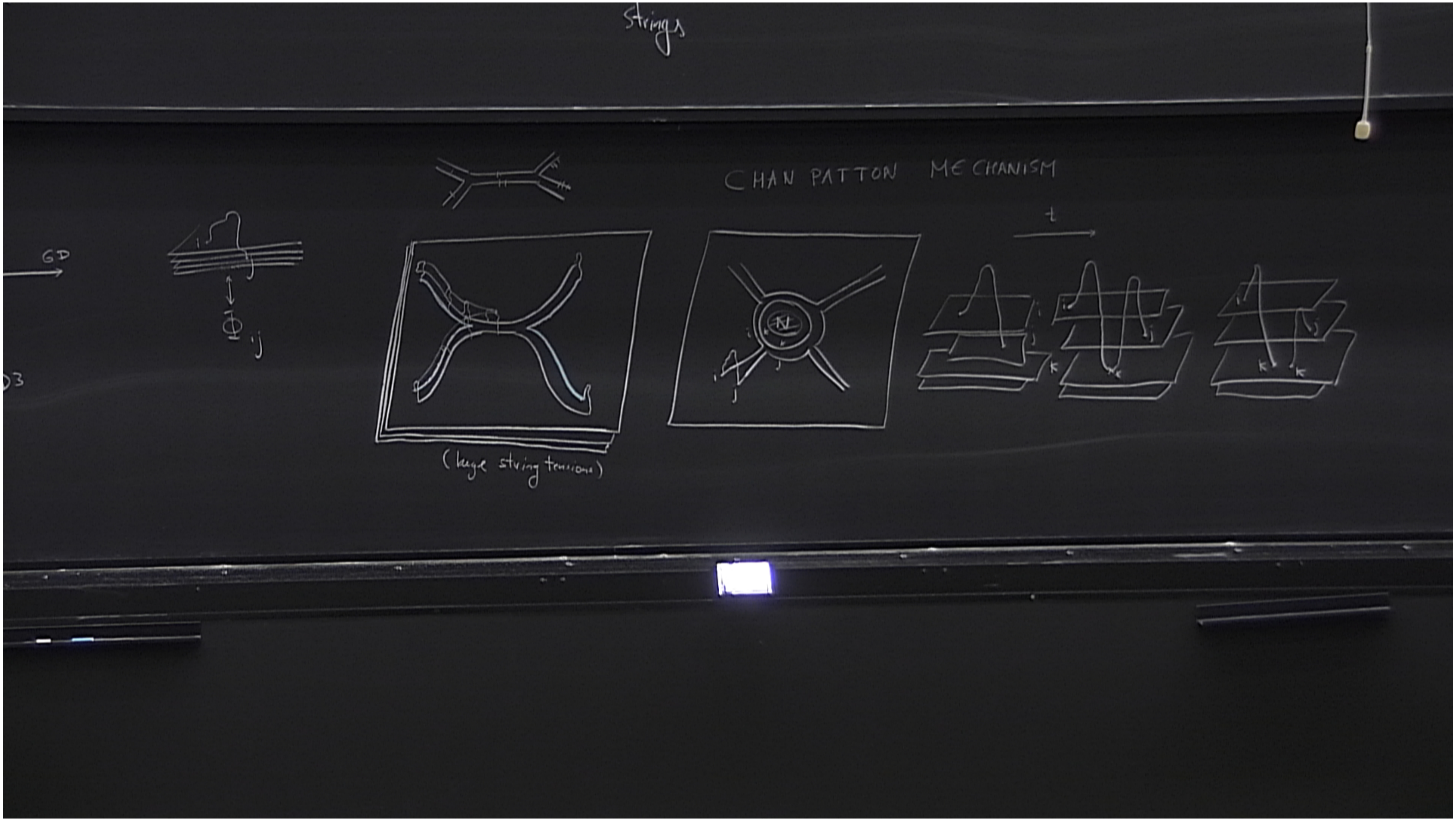
* What SYM is in (A)?
* What is the background in (B)?

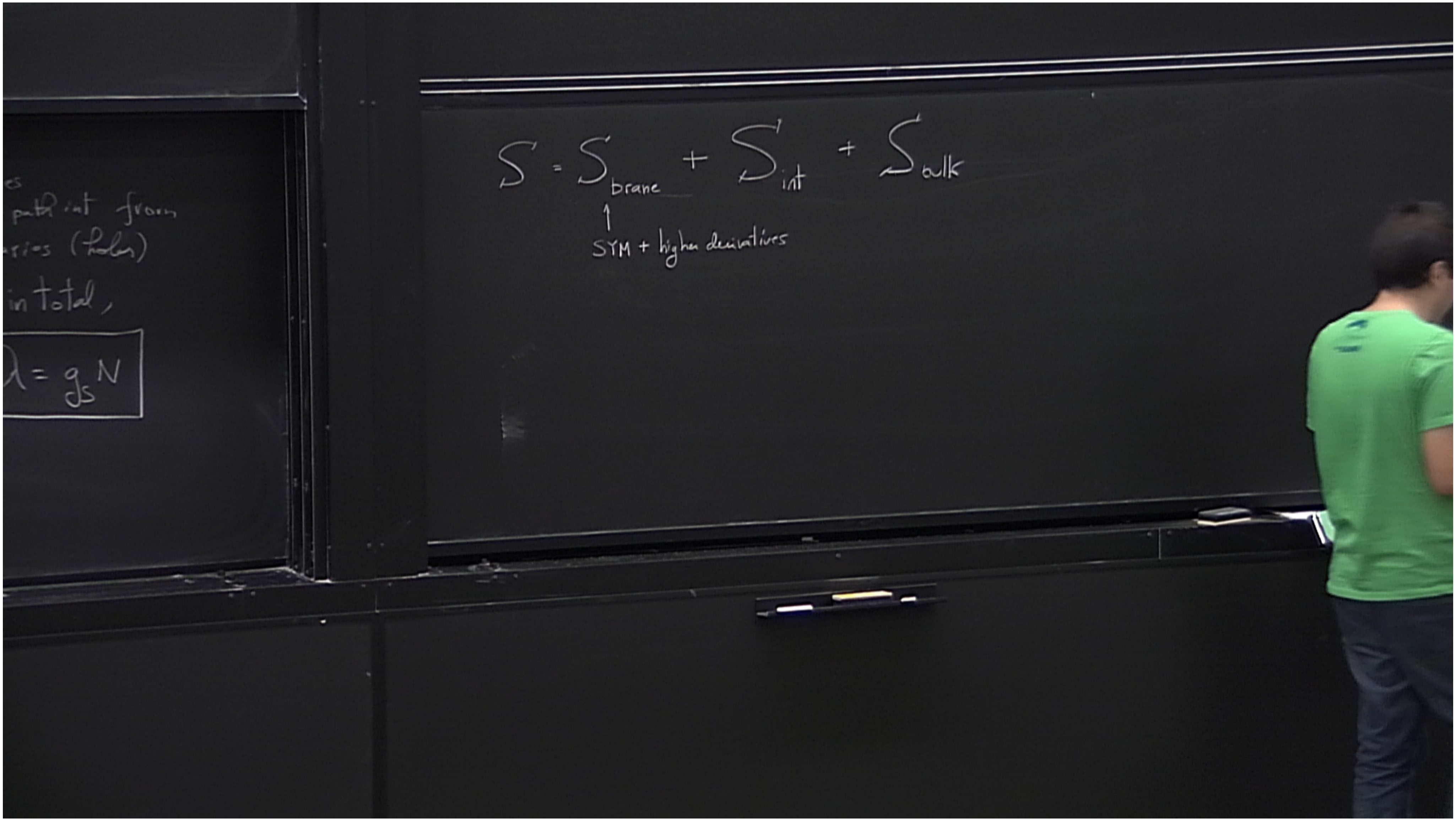

strings
3D
6D
N branes, D3
Φ_{ij}

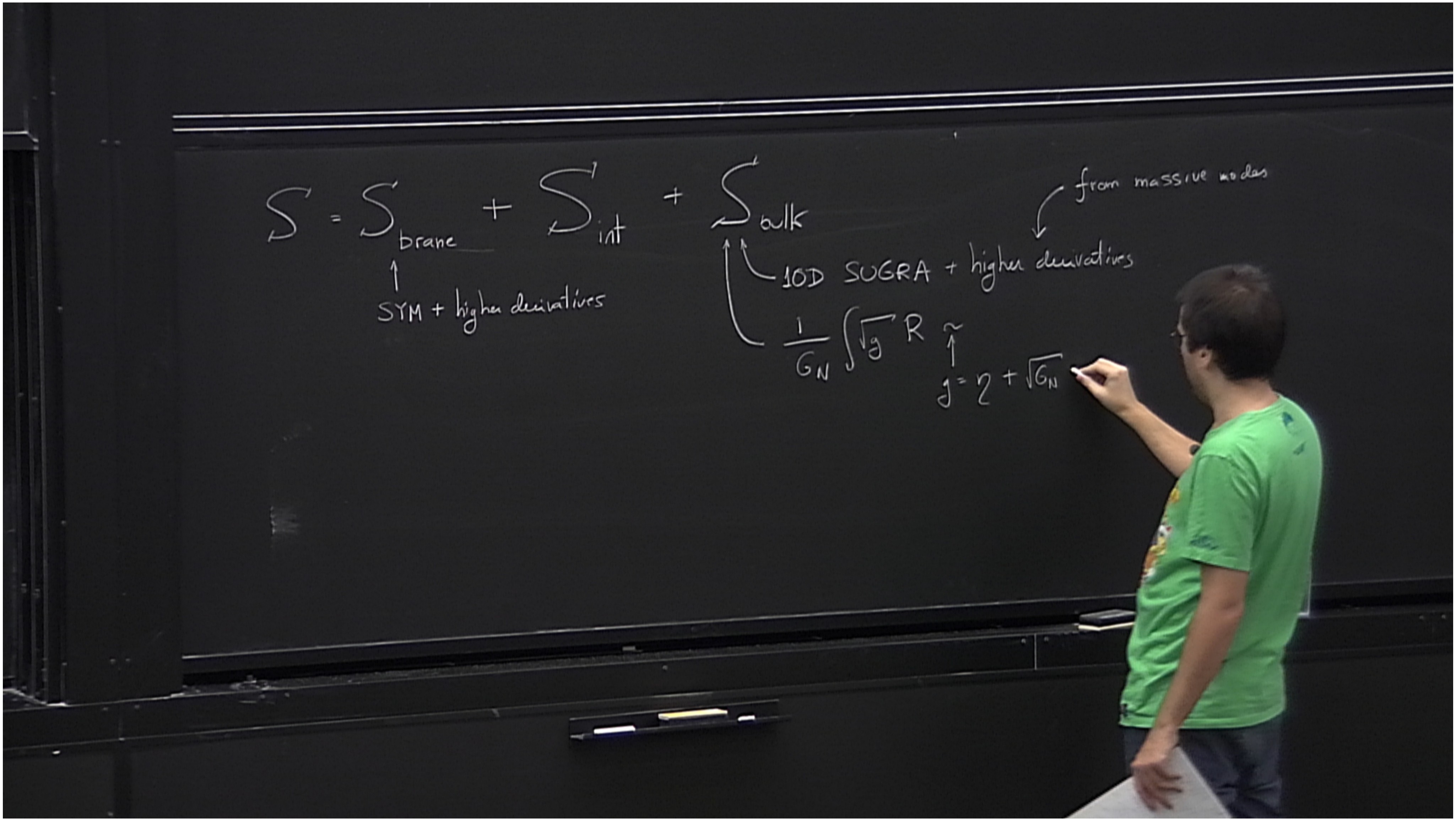


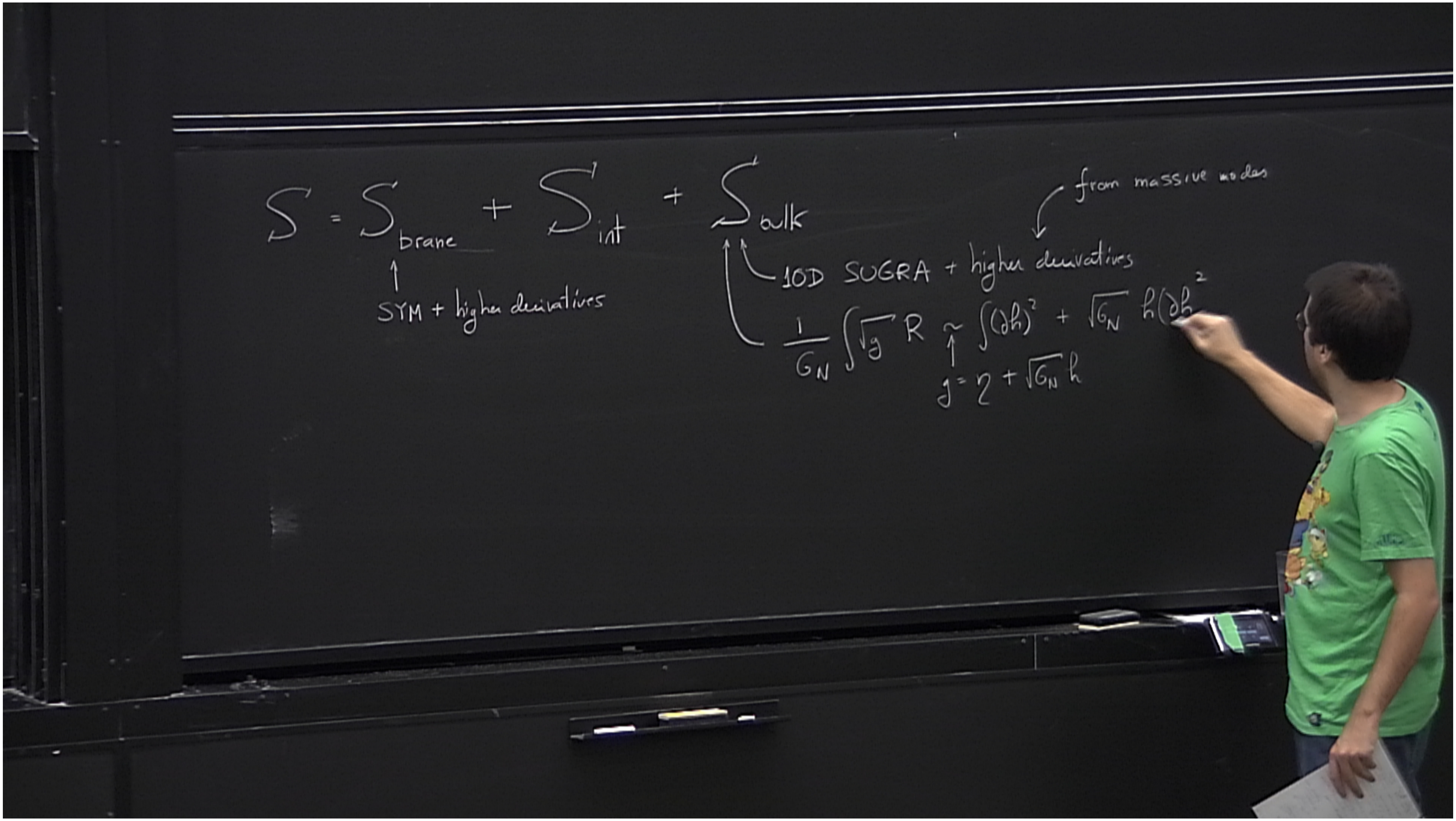
strings
3D
6D
N branes, D3
t


Strings
3D
6D
Φ_{ij}
(large string tensions)
t


Strings
CHAN PATTON MECHANISM
(large string tensions)


$S = S_{brane} + S_{int} + S_{bulk}$
SYM + higher derivatives
path int from
(holes)
in total,
$\lambda = g_s N$


S = S_brane + S_int + S_bulk
SYM + higher derivatives
from massive modes
10D SUGRA + higher derivatives
1/G_N ∫√g R ~
g = η + √G_N


$S = S_{brane} + S_{int} + S_{bulk}$
from massive modes
10D SUGRA + higher derivatives
SYM + higher derivatives
$\frac{1}{G_N}\int\sqrt{g}\,R \sim \int(\partial h)^2 + \sqrt{G_N}\,h(\partial h)^2$
$g = \eta + \sqrt{G_N}\,h$

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

S_{brane}: SYM + higher derivatives

S_{bulk}: 10D SUGRA + higher derivatives

from massive modes

$$\frac{1}{G_N}\int\sqrt{g}\,R \sim \int(\partial h)^2 + \sqrt{G_N}\,h(\partial h)^2 + \dots$$

$$g = \eta + \sqrt{G_N}\,h \qquad \sqrt{G_N} \sim g_s\,\alpha'^2$$

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

SYM + higher derivatives

(coupling λ)

dimensionless

from massive modes

10D SUGRA + higher derivatives

$$\frac{1}{G_N}\int\sqrt{g}\,R \sim \int(\partial h)^2 + \sqrt{G_N}\,h(\partial h)^2 + \dots$$

$$g = \eta + \sqrt{G_N}\,h \qquad \sqrt{G_N} \sim g_s\,\alpha'^2$$

dimensionful couplings (with α')

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

in fld space

from massive modes

S_{brane}: SYM + higher derivatives (coupling λ) ← dimensionless

S_{bulk}: 10D SUGRA + higher derivatives

$$\frac{1}{G_N}\int\sqrt{g}\,R \sim \int(\partial h)^2 + \sqrt{G_N}\,h(\partial h)^2 + \dots$$

$$g = \eta + \sqrt{G_N}\,h \qquad \sqrt{G_N} \sim g_s\,\alpha'^2$$

dimensionful couplings (with α')

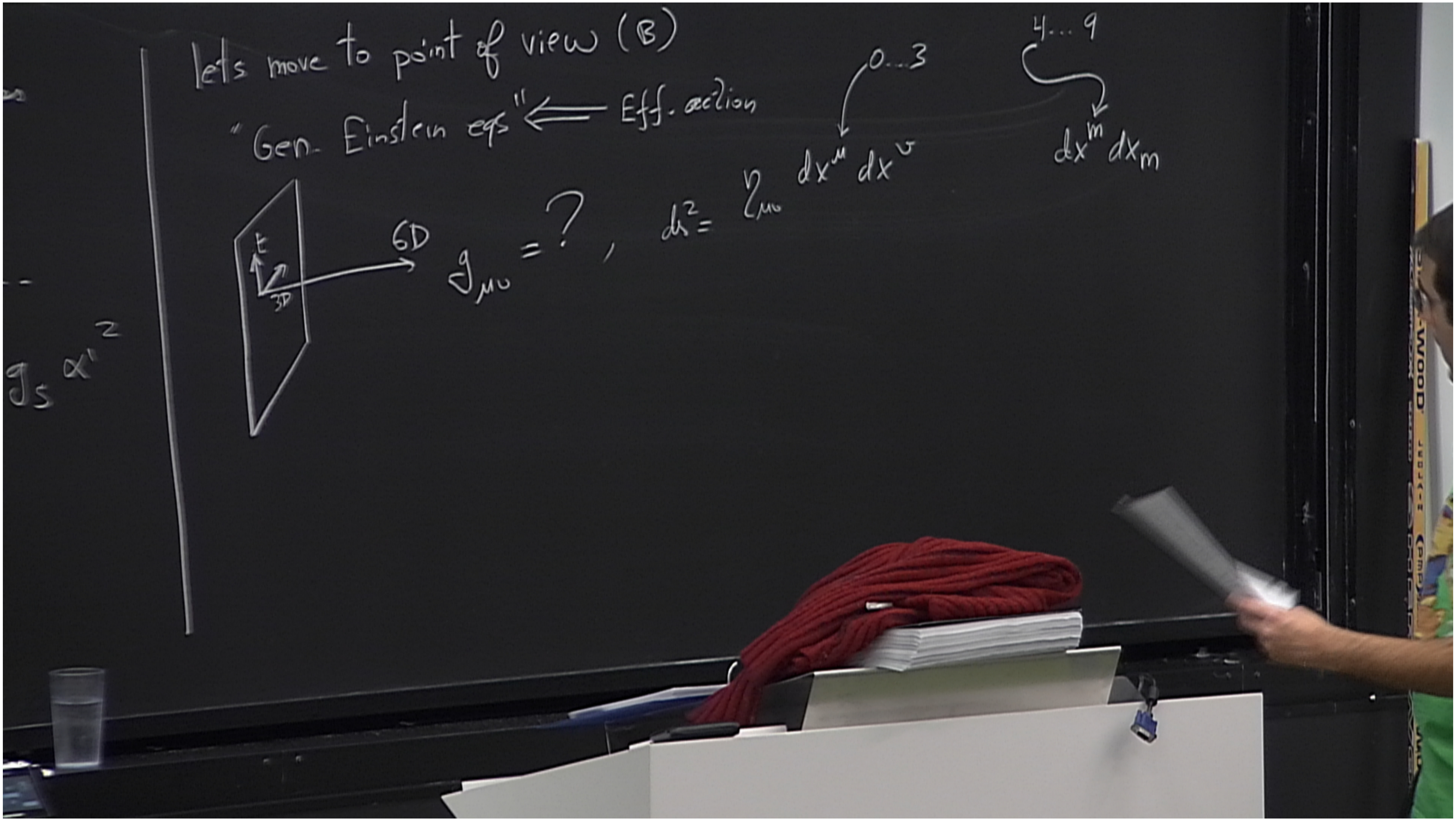
lets consider a low energy limit

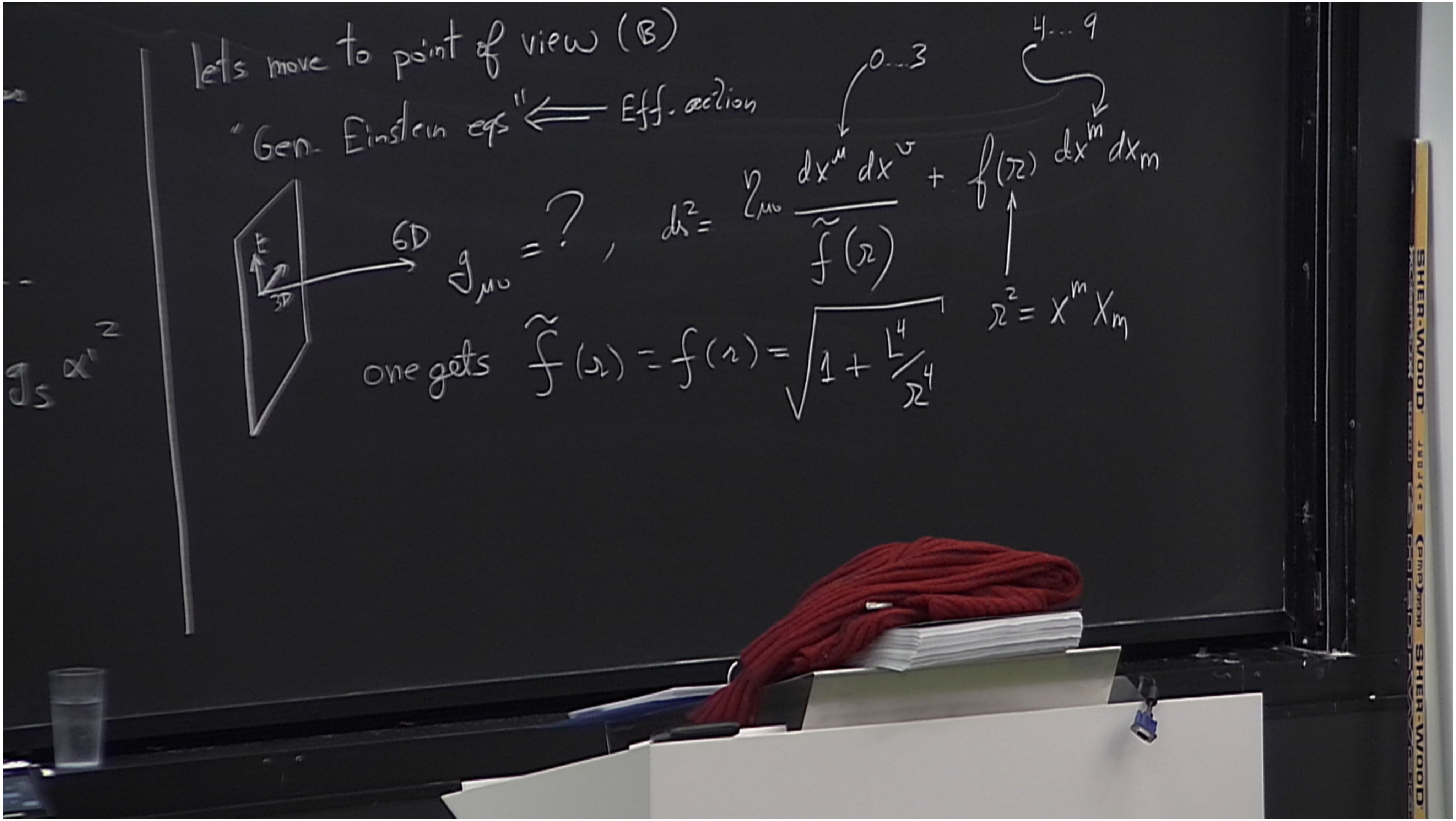
only survives

$$\alpha'\vec{k}^2 \ll 1, \quad |\vec{x}-\vec{x}'|^2/\alpha' \gg 1$$

in practise this amounts to taking $\alpha' \to 0$

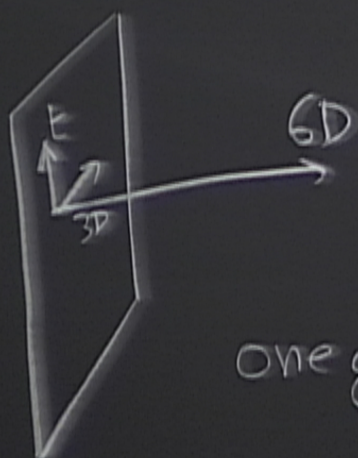
$(A) = $ 4D SYM $(\mathcal{N}=4) \oplus$ 10D SUGRA


lets move to point of view (B)
"Gen. Einstein eqs" ⟸ Eff. action
0...3
4...9
$dx^m dx_m$
$g_{\mu\nu} = ?$, $ds^2 = \eta_{\mu\nu} dx^\mu dx^\nu$
6D
3D
t
$g_s \alpha'^2$


lets move to point of view (B)
"Gen. Einstein eqs" $\Longleftarrow$ Eff. action
0...3
4...9
$ds^2 = \eta_{\mu\nu} \frac{dx^\mu dx^\nu}{\tilde{f}(r)} + f(r)\, dx^m dx_m$
6D
3D
$g_{\mu\nu} = ?$
one gets $\tilde{f}(r) = f(r) = \sqrt{1 + L^4/r^4}$
$r^2 = x^m x_m$
$g_s \alpha'^2$

lets move to point of view (B)

"Gen. Einstein eqs" $\Longleftarrow$ Eff. action



$g_{\mu\nu} = ?$, $ds^2 = \eta_{\mu\nu} \dfrac{\overset{0\ldots3}{dx^\mu dx^\nu}}{\tilde{f}(r)} + f(r)\, \overset{4\ldots9}{dx^m dx_m}$

$r^2 = x^m x_m$

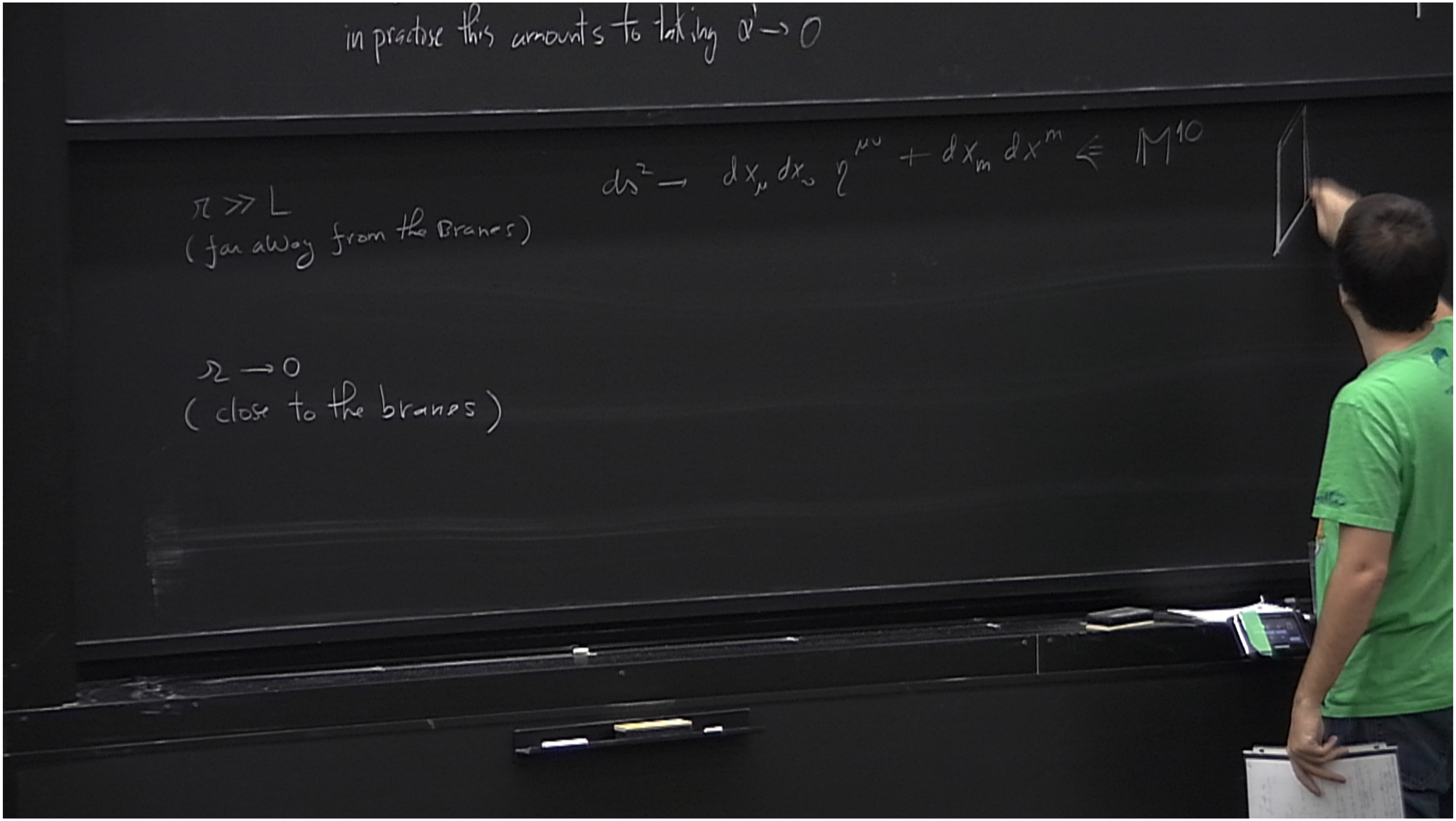
one gets $\tilde{f}(r) = f(r) = \sqrt{1 + L^4/r^4}$

$L^4 = g_s N 4\pi\alpha'$

N units of flux sourced by the N branes

good, useful, simple, for $g_s N = \lambda \ll 1$

$(A) = $ 4D SYM $(\mathcal{N}=4)$ $\oplus$ 10D SUGRA


in practise this amounts to taking $\alpha' \to 0$
$r \gg L$
(far away from the Branes)
$ds^2 \to dx_\mu dx_\nu \eta^{\mu\nu} + dx_m dx^m \Leftarrow M^{10}$
$r \to 0$
(close to the branes)

in practise this amounts to taking $\alpha' \to 0$

$r \gg L$
(far away from the Branes)

$$ds^2 \to dx_\mu dx_\nu \eta^{\mu\nu} + dx_m dx^m \in M^{10}$$

... we

$r \to 0$
(close to the branes)

$$ds^2 \to \frac{r^2}{L^2}\eta_{\mu\nu} dx^\mu dx^\nu + \frac{L^2}{r^2} dr^2 + L^2 d\Omega^2_{S^5}$$

4D,

$r \gg L$

(far away from the Branes)

$$ds^2 \to dx_\mu dx_\nu \eta^{\mu\nu} + dx_m dx^m \Leftarrow M^{10}$$

$r \to 0$

(close to the branes)

$$ds^2 \to \overbrace{\frac{r^2}{L^2}\eta_{\mu\nu} dx^\mu dx^\nu}^{\text{from } dx_\mu dx_\nu \eta^{\mu\nu}} + \overbrace{\frac{L^2}{r^2} dr^2 + L^2 d\Omega^2_{S^5}}^{\text{from the } dx_m dx^m \text{ part}}$$

metric of AdS_5

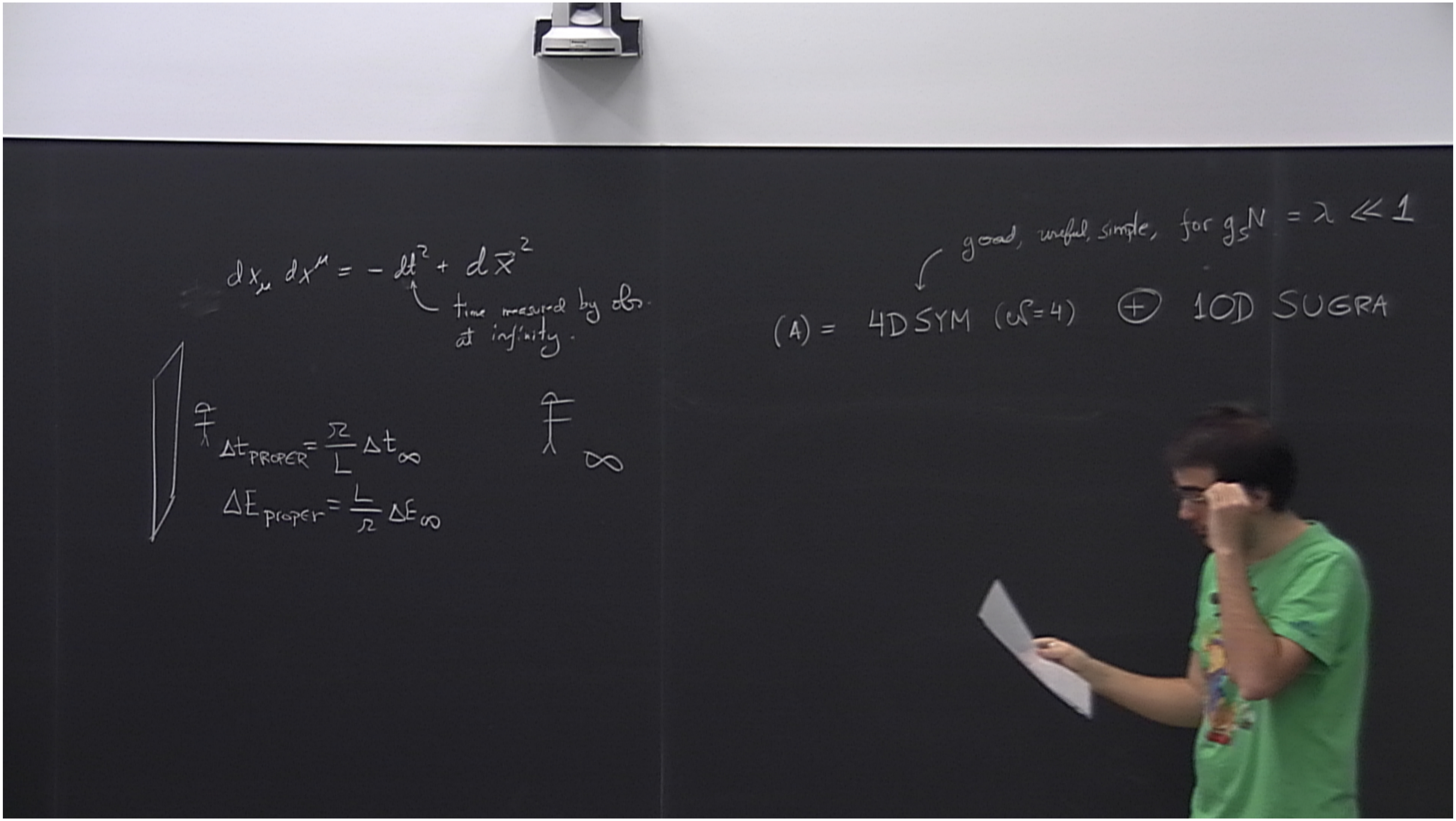
5 sphere, S^5

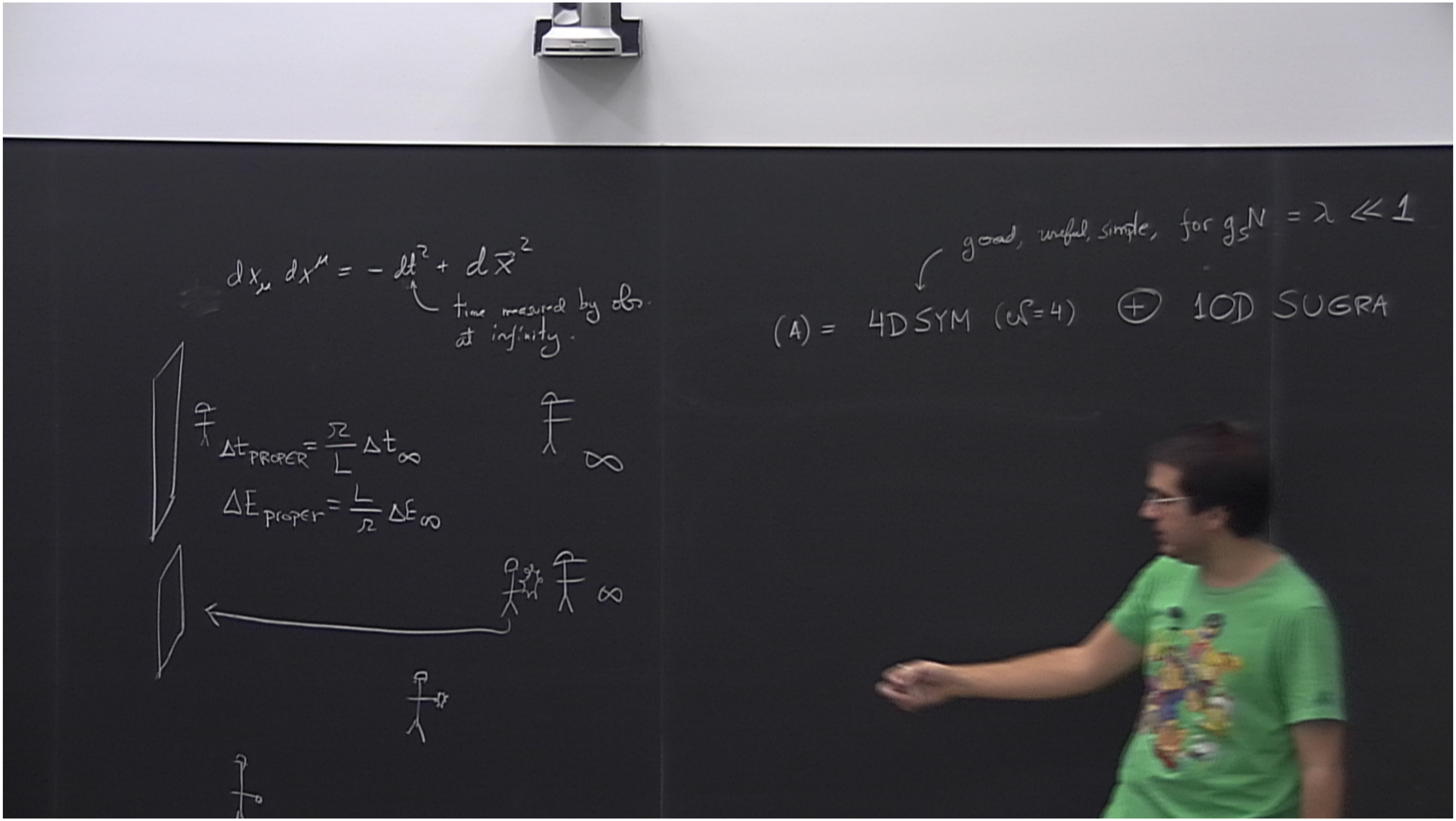
$$dx_\mu dx^\mu = -dt^2 + d\vec{x}^2$$

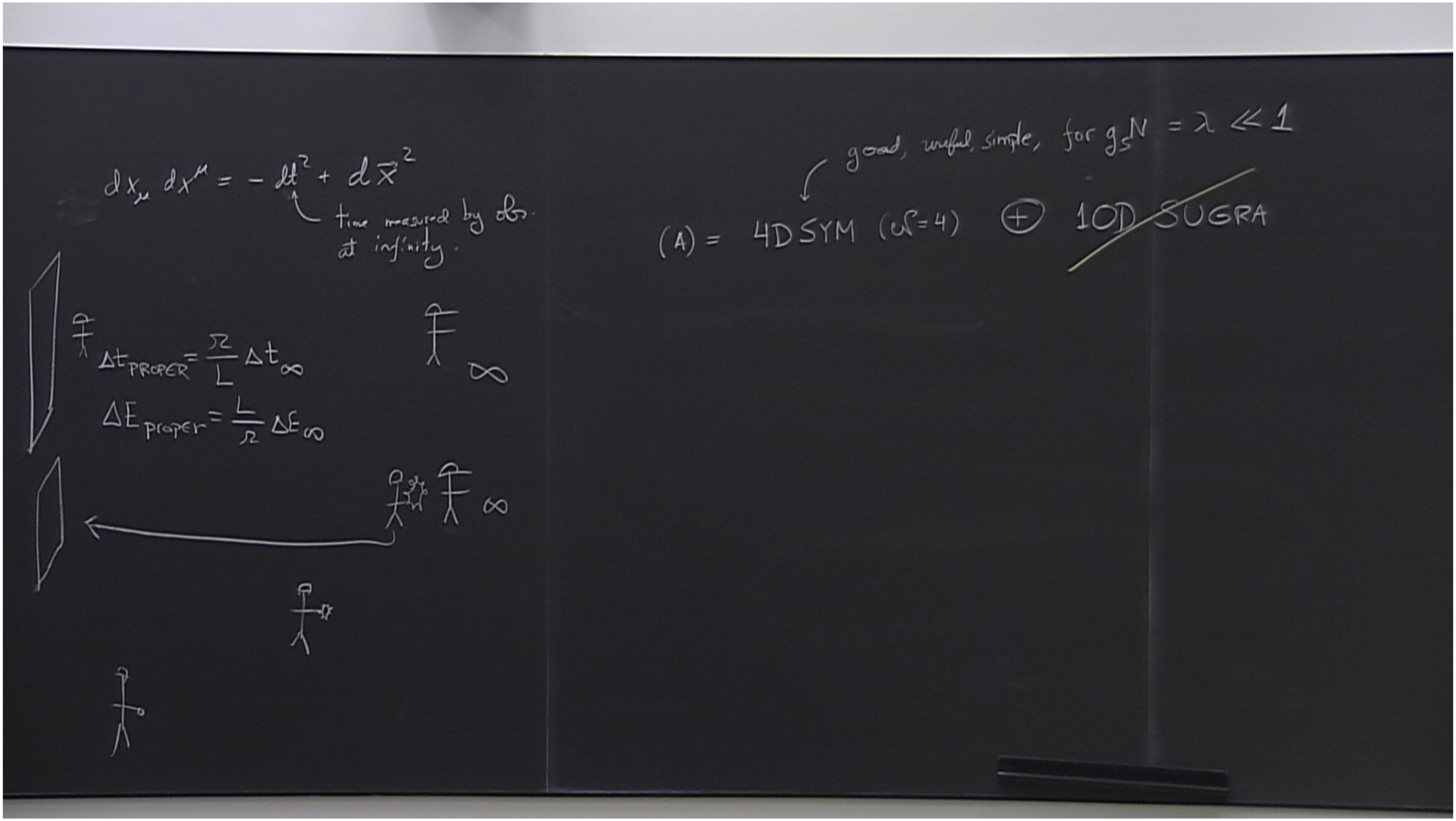
time measured by obs. at infinity.

good, useful, simple, for $g_s N = \lambda \ll 1$

$(A) =$ 4D SYM ($\mathcal{N}=4$) $\oplus$ 10D SUGRA


good, useful, simple, for $g_s N = \lambda \ll 1$
(A) = 4D SYM ($\mathcal{N}=4$) ⊕ 10D SUGRA
$dx_\mu dx^\mu = -dt^2 + d\vec{x}^2$
time measured by obs. at infinity.
$\Delta t_{PROPER} = \frac{\Omega}{L} \Delta t_\infty$
$\Delta E_{proper} = \frac{L}{\Omega} \Delta E_\infty$
∞


dx_μ dx^μ = − dt² + dx⃗²
time measured by obs. at infinity.
Δt_PROPER = Ω/L Δt_∞
ΔE_proper = L/Ω ΔE_∞
∞
good, useful, simple, for g_s N = λ ≪ 1
(A) = 4D SYM (N=4) ⊕ 10D SUGRA



$dx_\mu dx^\mu = -dt^2 + d\vec{x}^2$
time measured by obs. at infinity.
$\Delta t_{PROPER} = \frac{\Omega}{L} \Delta t_\infty$
$\Delta E_{proper} = \frac{L}{\Omega} \Delta E_\infty$
∞
∞
good, useful, simple, for $g_s N = \lambda \ll 1$
$(A) = 4D\,SYM\ (\mathcal{N}=4) \oplus \cancel{10D\ SUGRA}$