Title: Lecture - AdS/CFT, PHYS 777

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Collection/Series: AdS/CFT (Elective), PHYS 777, March 31 - May 2, 2025

Subject: Quantum Fields and Strings, Quantum Gravity

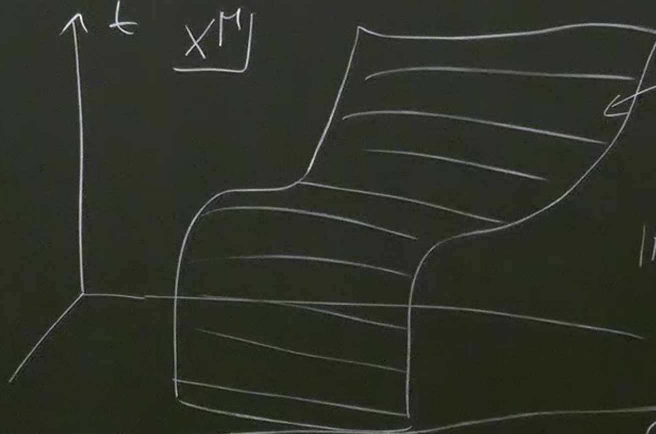
Date: April 07, 2025 - 9:00 AM

URL: https://pirsa.org/25040027

LAST TIME: P-BRANES ($(p+1)$-DIM WORLD VOLUMES)

• R

CARTOON 1:



WORLDVOLUME ... $X^\mu(\xi^A)$

ξ^A, $A = 0, \dots, p$

INDUCED METRIC: $\gamma_{AB}(\eta) = \eta_{\mu\nu} \dfrac{\partial X^\mu}{\partial \xi^A} \dfrac{\partial X^\nu}{\partial \xi^B}$

FREE MOTION:

$$\boxed{S_{NG}[X^\mu] = -T_p \int d^{p+1}\xi \sqrt{-\det(\gamma_{AB}(\eta))}}$$

$$\boxed{T_p = \frac{1}{(2\pi)^p \, l_s^{p+1}}}$$

• RELATIVISTIC MASSLESS STRINGS ($p=1$) EQUIVALENTLY DESCRIBED BY POLYAKOV ACTION:

$$\boxed{S[X^\mu, h^{AB}] = -\frac{T_2}{2}\int d^2\xi \sqrt{-h}\, h^{AB}\, \gamma_{AB}(\eta)}$$

"NON-LINEAR σ-MODEL"

+FERMIONS + BCS

QUANTIZE $\Rightarrow$ 5 SUPERSTRING THEORIES (IIB, . . .)

IN $d=10$ DIMENSIONS (TO PRESERVE LORENTZ SYMMETRY AT QUANTUM LEVEL)

EX: VECTOR IN $d=4$ DIMENSIONS

$$\nabla_\nu \boxed{\nabla_\mu F^{\mu\nu} + m^2 A^\nu = 0}$$

$\boxed{m=0}$

GAUGE SYM. $A_\mu \to A_\mu + \partial_\mu \Lambda$

ALLOWS TO IMPOSE $\nabla_\mu A^\mu = 0$

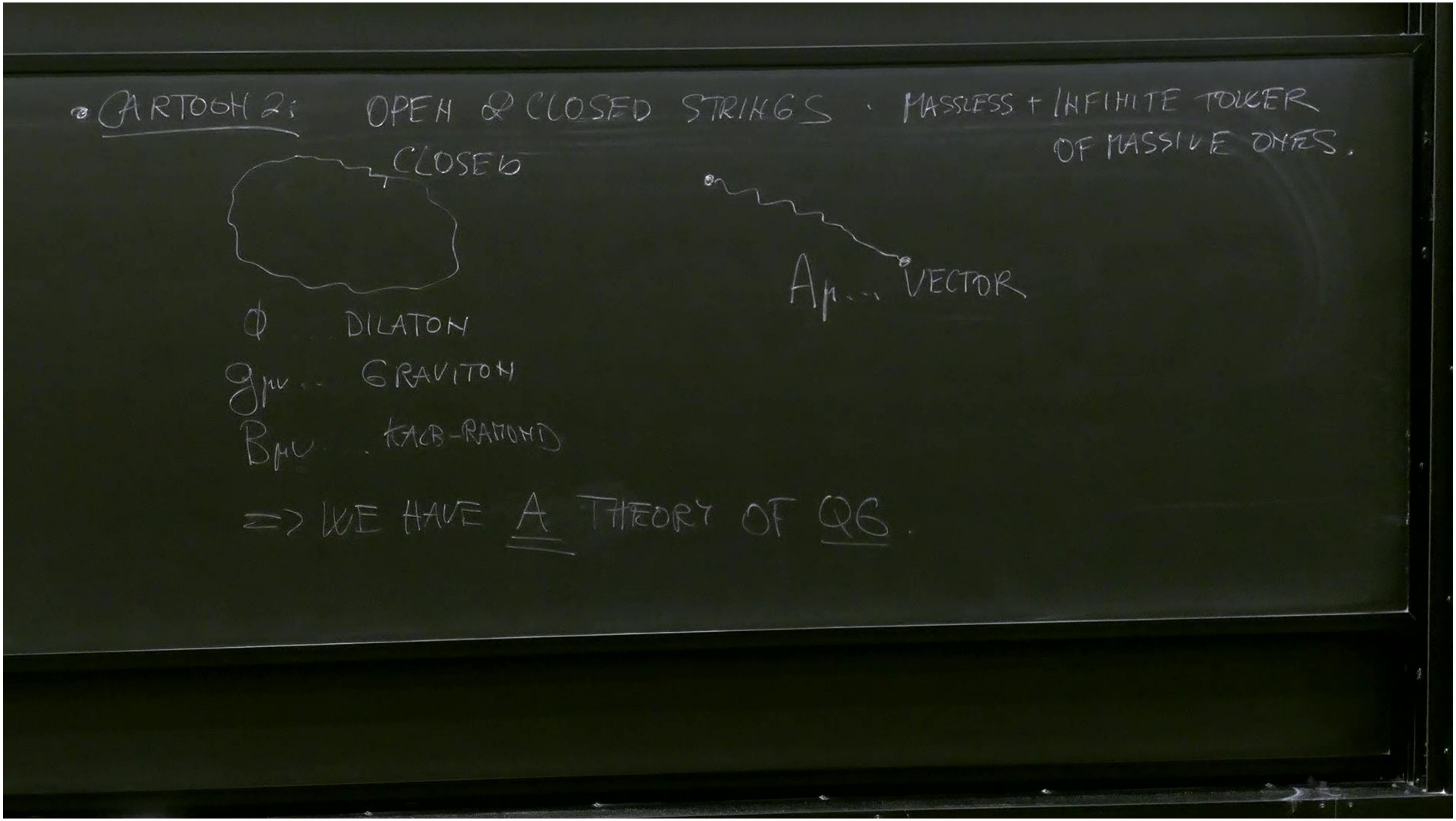
+ RES. SYMMETRY $\quad 4-2=2$ DOF

$\boxed{m\neq 0}$

$\nabla_\mu A^\mu = 0$

IS A CONS OF EOM.

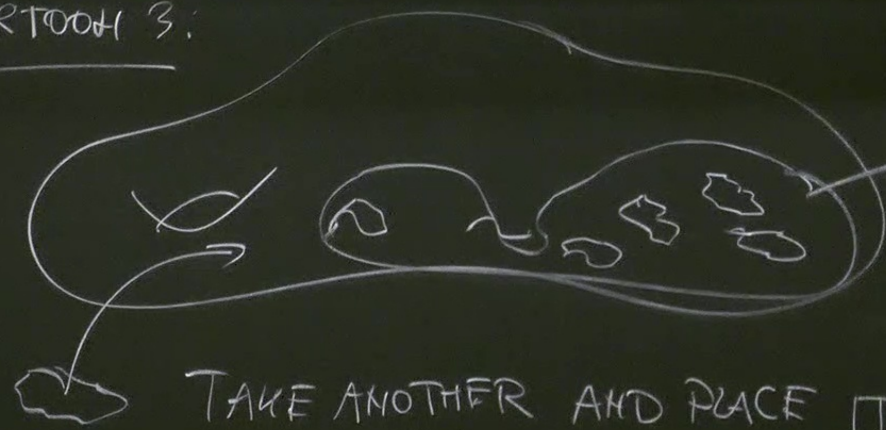
3 DOF


• CARTOON 2: OPEN & CLOSED STRINGS · MASSLESS + INFINITE TOWER
OF MASSIVE ONES.
CLOSED
A_μ ... VECTOR
ϕ ... DILATON
$g_{\mu\nu}$ ... GRAVITON
$B_{\mu\nu}$ ... KALB-RAMOND
=> WE HAVE A THEORY OF QG.

…LOWS TO IMPOSE $\partial_\mu A^\mu = 0$ $\boxed{3\ \text{DOF}}$

+ RES. SYMMETRY $4-2=2$ DOF,

CARTOON 3:



BACKGROUND FIELDS

$g_{\mu\nu}, B_{\mu\nu}, \phi, A_{\ldots}$

TAKE ANOTHER AND PLACE IT IN THIS BACKGROUND

IS ONLY CONSISTENT FOR CONSTRAINED BACKGROUNDS

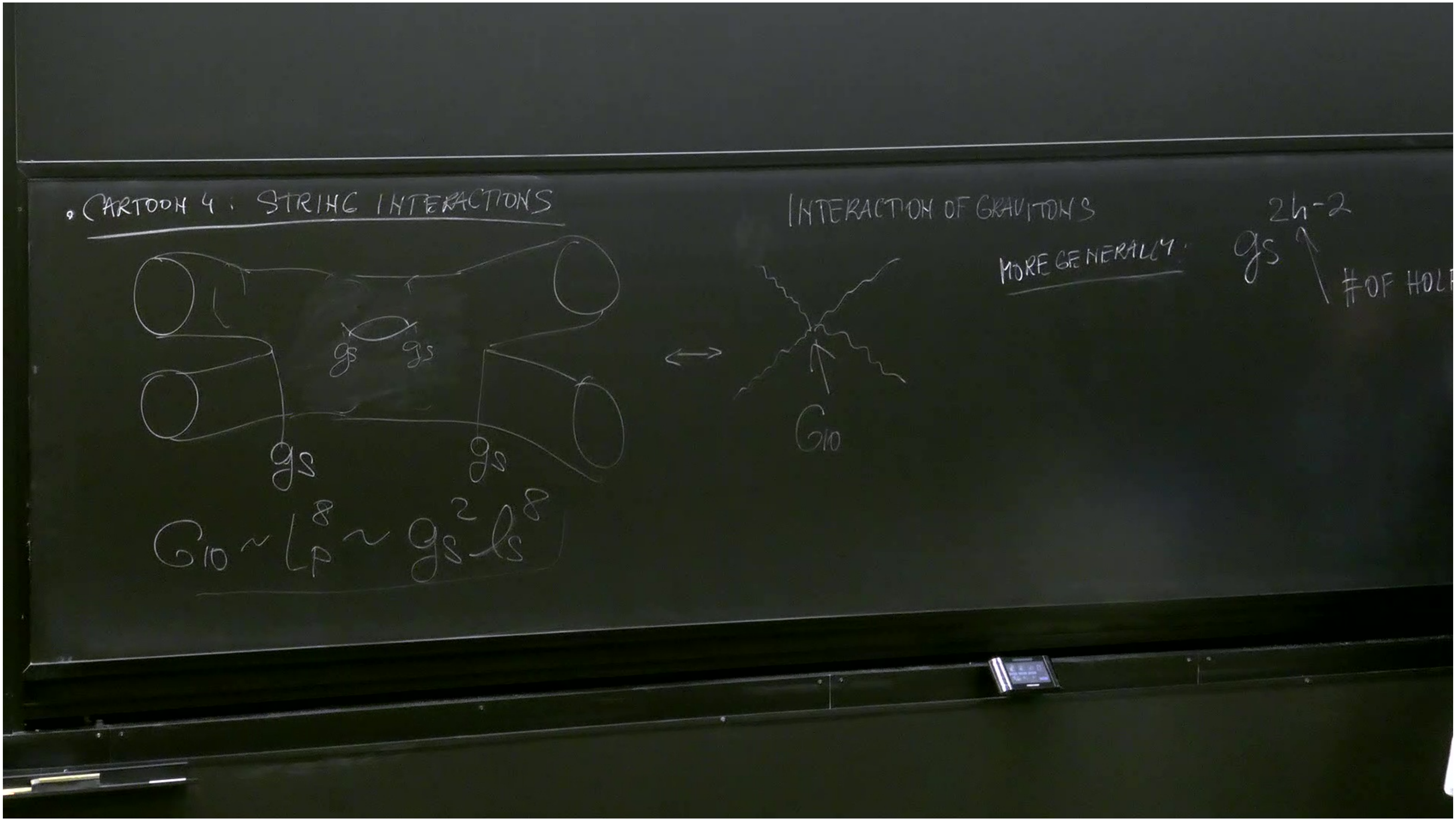
$$(\eta_{\mu\nu}) \to \gamma_{AB}(g_{\mu\nu})\, h^{AB} + \gamma_{AB}(B_{\mu\nu})\, \varepsilon^{AB} + \alpha\, \underline{R h}\, \phi + \dots$$

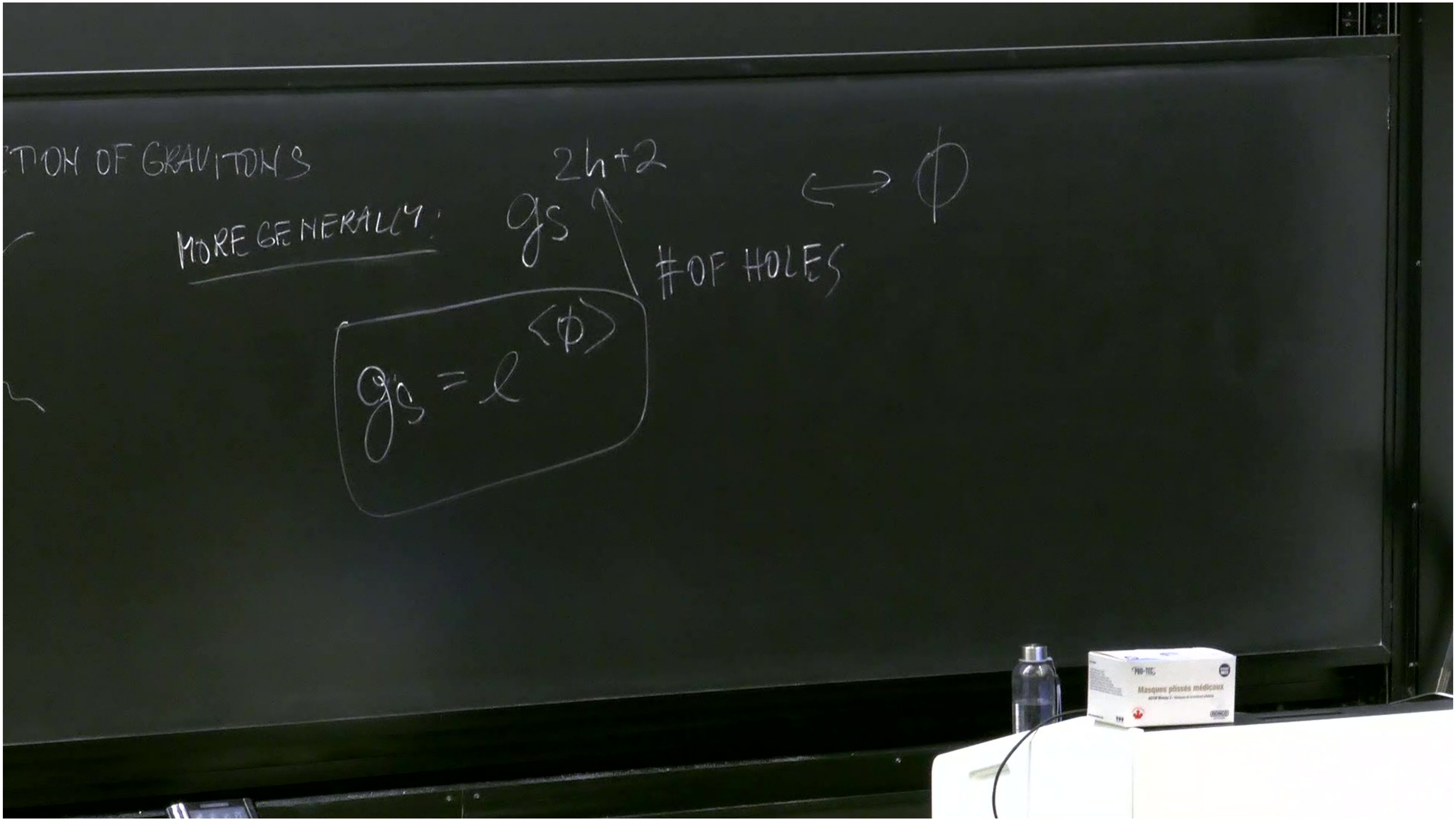
PRESERVE WEYL AT QUANTUM LEVEL

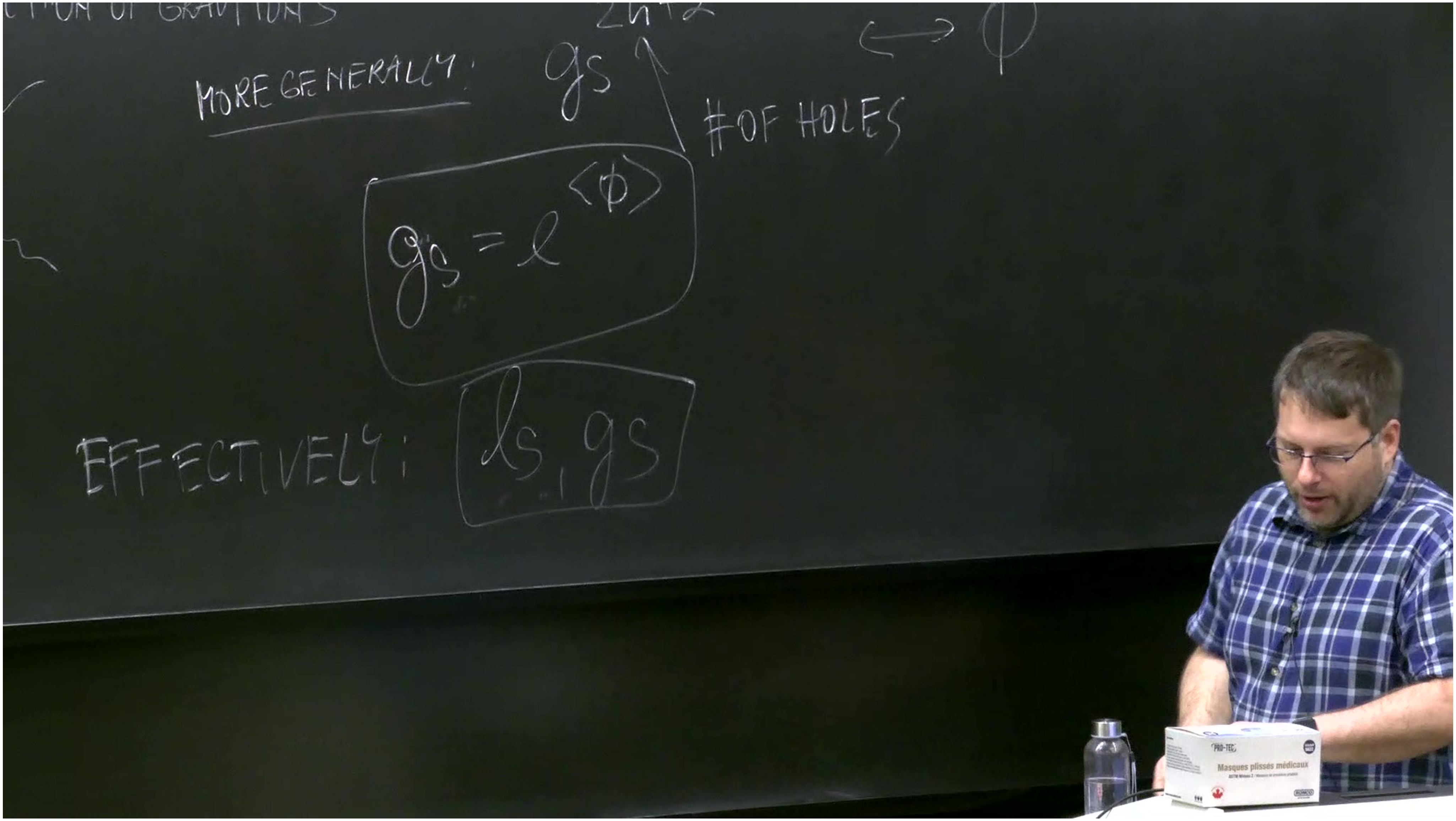
$$\boxed{\beta_{g_{\mu\nu}} = \beta_{\phi} = \beta_{B_{\mu\nu}} = 0}$$

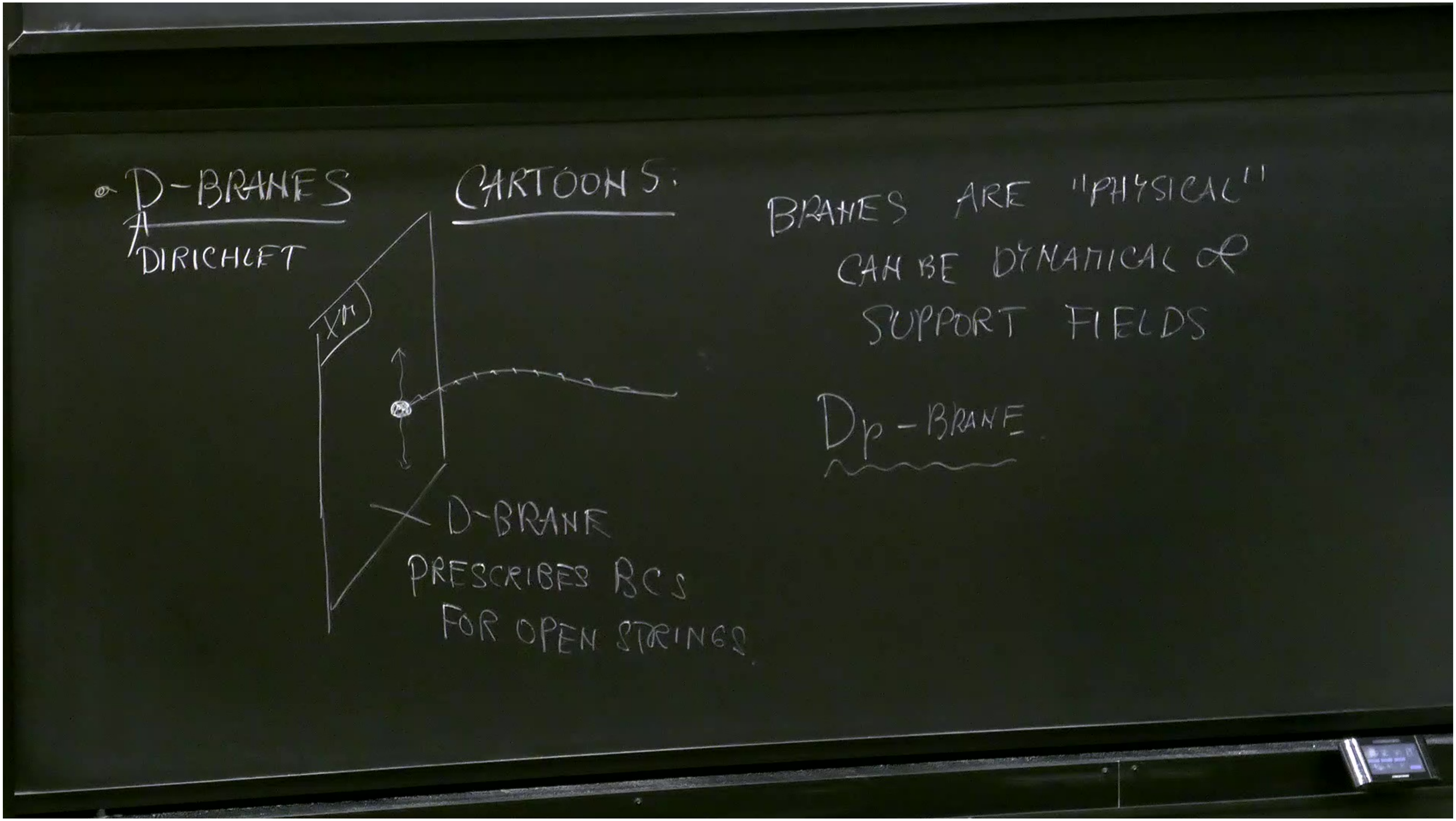
DERIVED FROM: "EINSTEIN EQUATIONS" IIB SUGRA EQUATIONS?

$$e^{-2\phi}\left(R + 4(\partial_\mu \phi)^2 - \frac{1}{2} H_3^2\right) - \frac{1}{2}\underset{\substack{\downarrow \\ A_0}}{F_1^2} - \frac{1}{2}\underset{\substack{\downarrow \\ A_2}}{F_3^2} - \frac{1}{4}\underset{\substack{\downarrow \\ A_4}}{F_5^2} - \frac{1}{2} A_4 \wedge H_3 \wedge F_3$$


CARTOON 4: STRING INTERACTIONS
gs
gs
gs
gs
G10 ~ lp^8 ~ gs^2 ls^8
INTERACTION OF GRAVITONS
G10
MORE GENERALLY:
gs^2h-2
#OF HOL


TION OF GRAVITONS
MORE GENERALLY:
g_s^{2h+2}
OF HOLES
$\longleftrightarrow \phi$
$g_s = e^{\langle \phi \rangle}$
Masques plissés médicaux


MORE GENERALLY:
gs
# OF HOLES
gs = e^⟨φ⟩
EFFECTIVELY:
ls, gs
Masques plissés médicaux


D-BRANES
DIRICHLET
CARTOONS:
X^M
D-BRANE
PRESCRIBES BCs
FOR OPEN STRINGS
BRANES ARE "PHYSICAL"
CAN BE DYNAMICAL &
SUPPORT FIELDS
Dp-BRANE

MOTION OF SINGLE BRANE GOVERNED BY

DIRAC-BORN-INFELD ACTION

$$\boxed{S_{DBI} = -T_p \int d^{p+1}\xi \, e^{-\phi} \sqrt{-\det\left(g_{AB}(g) + g_{AB}(B) + 2\pi\alpha' F_{AB}\right)}}$$

VECTORS

SCALARS

$B=0$, $e^{\phi}=g_s$, $g=\eta$, F_{AB} IS WEAK

$$\det(1+A) = 1 - \frac{1}{2}\mathrm{Tr}\, A^2 + O(A^4)$$

↑ ANTISYMM.

$\langle Z_i \, Z_j \rangle \sim \frac{1}{|i-j|^{1/4}}$

$$S_{DBI} \simeq -\underbrace{(2\pi\alpha')^2 \frac{T_p}{g_s}}_{\frac{1}{g_{YM}^2}} \int d^{p+1}\xi \, F_{AB}F^{AB} + O(F^4)$$

$$\boxed{g_{YM}^2 = \frac{g_s}{T_p(2\pi\alpha')^2} = (2\pi)^{p-2} g_s \, l_s^{p-3}}$$