Title: Learning Holography from Defects

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Collection/Series: Perimeter Graduate Conference 2025

Date: October 17, 2025 - 5:20 PM

URL: https://pirsa.org/25100192

Abstract:

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Learning Holography from defects

Raquel Izquierdo García

[Maldacena '98]

$\mathcal{N}=4$ super-Yang Mills

with gauge group $U(N)$ in 4 dimensions

coupling g^2_{YM}

HOLOGRAPHIC DUALITY

$g^2_{YM} = 2\pi g_s$

$g^2_{YM} N = \frac{L^4}{2\alpha'^2}$

Type IIB string theory on $AdS_5 \times S^5$

string length $l_s = \sqrt{\alpha'}$

coupling g_s

radius of AdS_5, S^5 L

Flux $\int_{S^5} F_5 = N$

't Hooft limit /

Planar limit : $N \to \infty$

$g_s \to 0$

$\frac{\alpha'}{L^2} \to 0$

SUPERGRAVITY

STRONG/WEAK DUALITY

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How do we get to the CFT_d / AdS_{d+1} story?

CONSISTENT TRUNCATION

Type IIB supergravity on $AdS_5 \times S^5$

(?!)

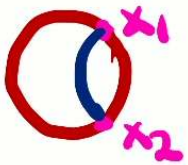
Kaluza-Klein reduction + truncation

gauged supergravity on AdS_5

[Witten '98, Gubser, Klebanov, Polyakov '98] ...

In the last 25/30 years [...]

- checked that symmetries match
- worked in the **HOLOGRAPHIC DICTIONARY**

CFT$_d$	AdS$_{d+1}$
local op. $\mathcal{O}_\Delta$	field ϕ w/ $m^2L^2 = \Delta(\Delta-d)$ ← scalar
$\langle \mathcal{O}\,\mathcal{O}\dots\mathcal{O}\rangle$	$\langle \phi\,\phi\dots\phi\rangle$ w/ Witten diag
$\langle \mathcal{O}(x_1)\mathcal{O}(x_2)\rangle$	$\langle \phi\,\phi\rangle =$ 
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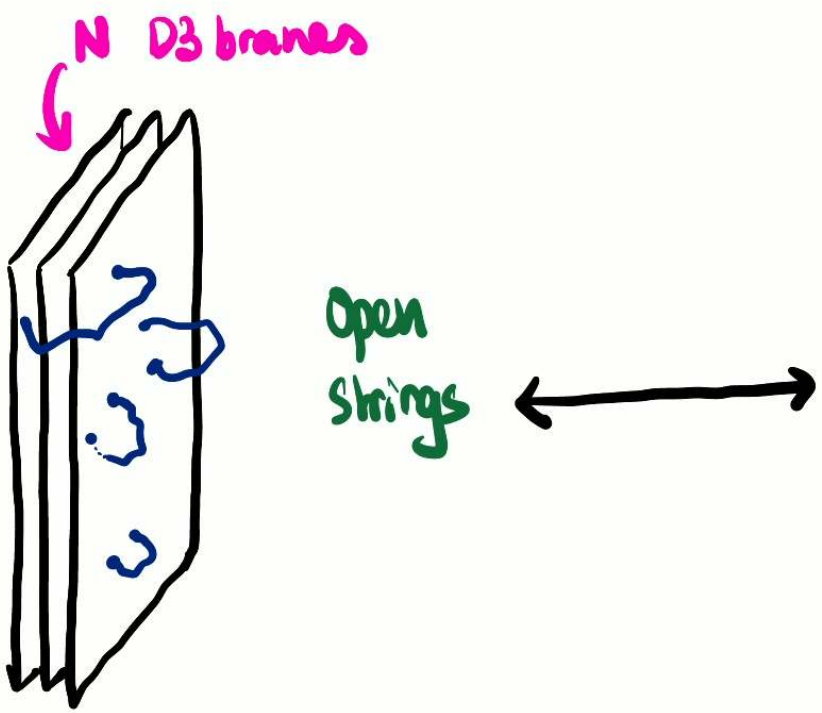
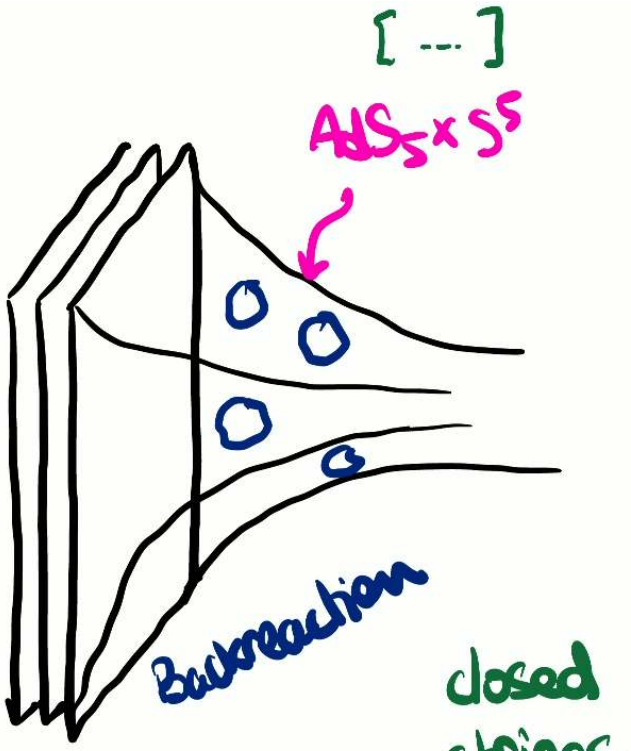


Open strings



$\mathcal{N}=4$ SYM

lives on the branes

$(g_s N \to 0)$

Type IIB SUGRA

on $AdS_5 \times S^5$ $(g_s N \to \infty)$

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We want to know how to build a holographic dual for any operator / defect.

$m^2 \sim \Delta^2 \Rightarrow$

precise for Chiral Primary Operators

- $\Delta \sim O(1)$ — gravitons [Witten '98] — perturbation of $AdS_5 \times S^5$
- $\Delta \sim O(N)$ — giant gravitons — probe brane in $AdS_5 \times S^5$ [McGreevy, Tambu, Susskind '00]
- $\Delta \sim O(N^2)$ — NEW GEOMETRY [Lin, Lunin, Maldacena '04] — Bubbling Geometries

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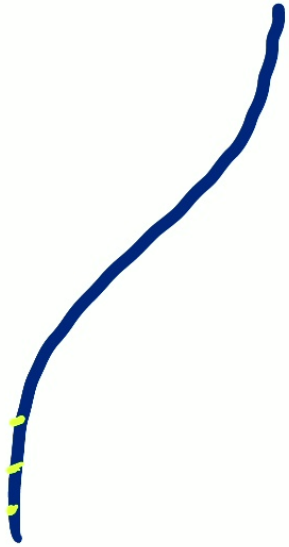
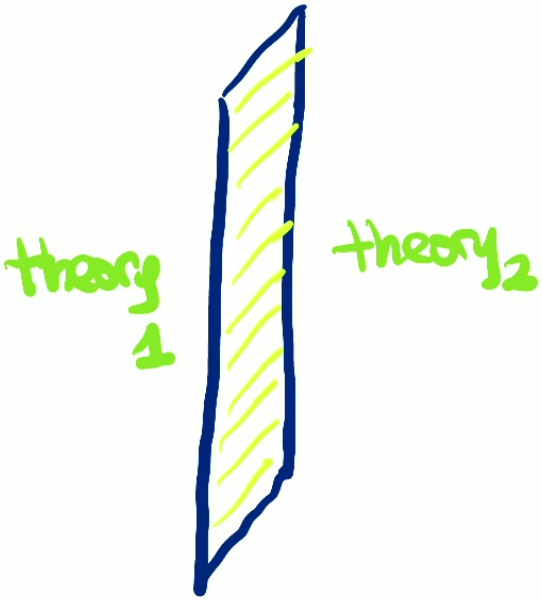
There is a lot of physics in NON-LOCAL OPERATORS



line operators

surface operators



interfaces, boundaries

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In supersymmetric theories, [many many people]

with supersymmetric operators :

$\langle \mathcal{O} \rangle$, $\langle \mathcal{O} \rangle$ . . . exactly

And holographic duals can be constructed !

- Brane intersection systems
- New geometries : soln' to SUGRA with the right asymptotics

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Surface Operators in 4d $\mathcal{N}=4$ SYM

[Gukov, Witten '06]

$$\left\langle \; \bigcirc_{r} \; \right\rangle \propto r^{b/3}$$

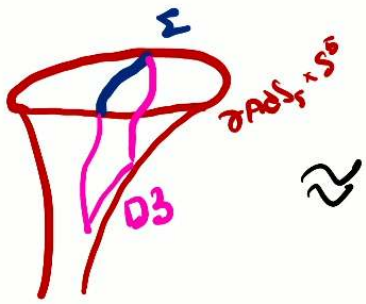
($b/3$: anomaly)

$$b = 3(\dim \mathfrak{G} - \dim \mathbb{L})$$

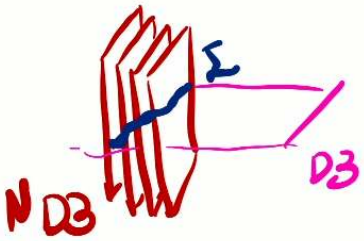
(exact)

$b \sim \Theta(N)$

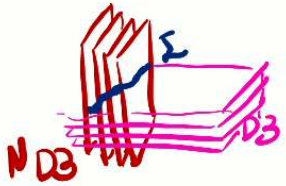
$b \sim \Theta(N^2)$



$\approx$



[Constable, Erdmenger, Gursalnik, Kirsch '02]



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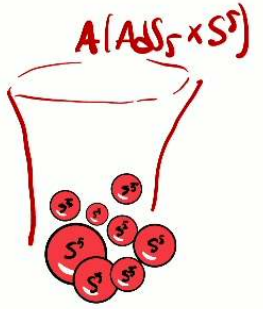

[Gomis, Matsuura '07]

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The eom of type IIB SUGRA are VERY hard

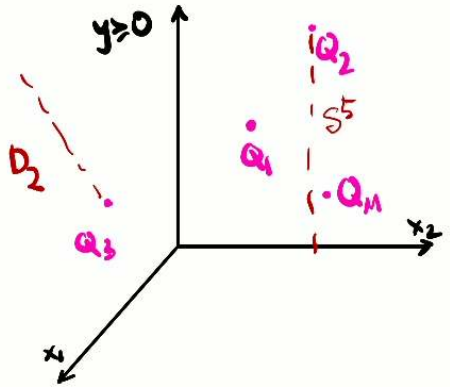
$g, \phi, B_2, C_0, C_2, C_4$

people use symmetries ⟵ esp. susy

to constrain the problem

$$ds^2 = y\sqrt{\frac{2z+1}{2z-1}}\, ds^2_{AdS_3} + y\sqrt{\frac{2z-1}{2z+1}}\, ds^2_{S^3} + \frac{2y}{\sqrt{4z^2-1}}(d\chi + V)^2 + \frac{\sqrt{4z^2-1}}{2y}(dy^2 + dx_i\, dx_i),$$

$$F_{(5)} = -\frac{1}{4}\left[d\left(y^2\frac{2z+1}{2z-1}(d\chi+V)\right) - y^3 \star_X d\left(\frac{1}{y^2}\left(z+\frac{1}{2}\right)\right)\right] \wedge \mathrm{vol}_{AdS_3} +$$
$$-\frac{1}{4}\left[d\left(y^2\frac{2z-1}{2z+1}(d\chi+V)\right) - y^3 \star_X d\left(\frac{1}{y^2}\left(z-\frac{1}{2}\right)\right)\right] \wedge \mathrm{vol}_{S^3},$$



9/11 all other fields are zero!

- There is no consistent truncation
  - ↳ geometry $\neq X_5 \times M^5$
- Holographic Renormalization "doesn't work"
- Kaluza Klein Holography [Skenderis, Taylor '06]
  - ↳ $\langle$  $\cdot\, \mathcal{O}_{\Delta}(x) \rangle$ but hard and $\Delta \leq 4$
- We want to compute anomalies like

$\langle$  $\rangle$

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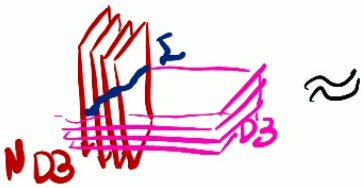
In 2010's : [many people!]

- interfaces
- Wilson lines, 't Hooft lines
- Surface ops

in $\mathcal{N}=4$ SYM and many other theories!

Today :

- defects
- matrix models



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