SURFACE DEFECTS IN MASSIVE IIA

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Introduction and Motivations

- Some branes (or their bound states) include closed string AdS vacua in their near-horizon.
- **AdS/CFT correspondence**: Dual description of AdS vacua at the horizon as RG fixed point of the worldvolume QFT of the brane. These fixed points are given by strongly-coupled SCFTs in the large N limit.
  [Maldacena. 1997.] [Witten. 1998.].
- Consistent truncations to d-dimensional gauged supergravities $\longrightarrow$ RG flow across dimensions, conformal defects...
  [Boonstra, Skenderis, Townsend. 1998.] [Maldacena, Nunez. 2000.]
  [Karch, Randall. 2001.].

Outline

- Conformal defects and holography.
- Gauged Supergravity Setup.
- Solutions with non-trivial p-form gauge potentials.
- Charged DW in $d = 7$: AdS_3 slicing and brane picture in massive IIA.
- Defect SCFT_2 within the $\mathcal{N} = (1, 0)$ SCFT_6.

Holographic Defects

We want to describe the physics of some branes ending on a known brane intersection featured by an AdS vacuum at the horizon.

Supergravity Picture of a Conformal Defect

Asymptotically AdS_d warped solutions $\mathrm{AdS}_{p+2} \times_w \mathcal{M}_{d-p-2}$ in a d-dimensional gauged supergravity are dual to defect SCFT_{p+1} within the SCFT_{d-1} dual to the AdS_d in the asymptotics. [Karch, Randall. 2001.].

$$ds_d^2 = e^{2U(r)} ds^2_{\mathrm{AdS}_{p+2}} + e^{2V(r)} dr^2 + e^{2W(r)} ds^2_{d-p-3} \,.$$

Supergravity Setup

We consider massive IIA string theory and the following consistent truncations:

- **NS5-D6-D8** and $\mathrm{AdS}_7 \times_w \tilde{S}^3$ vacua $\rightarrow$ minimal $\mathcal{N}=1$ gauged supergravity in $d=7$: $(g_{\mu\nu}, X, B_{(3)}, A^i)$.

  [Townsend, van Nieuwenhuizen. 1983.] [Hanany, Zaffaroni. 1998] [Imamura, 2001] [Apruzzi, Fazzi, Rosa, Tomasiello. 2013.] [Gaiotto, Tomasiello. 2014.] [Passias, Rota, Tomasiello. 2015.]

- **D4-D8** and $\mathrm{AdS}_6 \times_w S^4$ vacua $\rightarrow$ minimal $\mathcal{N}=(1,1)$ $F(4)$ gauged supergravity in $d=6$: $(g_{\mu\nu}, X, B_{(2)}, A^0, A^i)$.

  [Romans. 1984.] [Seiberg. 1996.] [Brandhuber, Oz. 1999.] [Ferrara, Kehagias, Partuche, Zaffaroni. 1998.] [Cvetic, Lu, Pope. 1999.] [Jafferis, Pufu. 2012.]

Bulk Geometry with p-Forms

- Backgrounds BPS/2 with AdS_7 asymptotics:

$$ds_7^2 = e^{2U(r)}\, ds^2_{\mathrm{AdS}_3} + e^{2V(r)}\, dr^2 + e^{2W(r)}\, ds^2_{\Sigma_3}\,,$$
$$B_{(3)} = k(r)\, \mathrm{vol}_{\mathrm{AdS}_3} + l(r)\, \mathrm{vol}_{\Sigma_3}\,,$$
$$X = X(r)\,,$$

where $\Sigma_3 = \{\mathbb{R}^3, S^3\}$. [Dibitetto, N.P. 2017.]

- Backgrounds BPS/2 with AdS_6 asymptotics:

$$ds_6^2 = e^{2U(r)}\, ds^2_{\mathrm{AdS}_3} + e^{2V(r)}\, dr^2 + e^{2W(r)}\, ds^2_{\Sigma_2}\,,$$
$$B_{(2)} = b(r)\, \mathrm{vol}_{\Sigma_2}$$
$$X = X(r)$$

where $\Sigma_2 = \{\mathbb{R}^2, S^2\}$. [Dibitetto, N.P. 2018.]

An Example: Charged DW in $d = 7$

- The Killing spinor is very simple (8 supercharges): $\epsilon(r) = Y(r)\,\epsilon_0$.

$$ds_7^2 = e^{2U(r)}\,(ds^2_{\mathrm{AdS}_3} + ds^2_{S^3}) \,+\, e^{2V(r)}\,dr^2\,,$$
$$B_{(3)} = k(r)\,(\mathrm{vol}_{\mathrm{AdS}_3} \,+\, \mathrm{vol}_{S^3})\,.$$

- BPS flow with $r \in (0,1)$:

$$e^{2U} = \frac{2^{-1/4}}{\sqrt{g}}\left(\frac{r}{1\,-\,r^5}\right)^{1/2}\,,\quad e^{2V} = \frac{25}{2g^2}\,\frac{r^6}{(1\,-\,r^5)^2}\,,$$
$$Y = \frac{2^{-1/16}}{g^{1/8}}\left(\frac{r}{1\,-\,r^5}\right)^{1/8}\,,\quad k = -\frac{2^{1/4}\,R_{\mathrm{AdS}_3}}{g^{3/2}}\left(\frac{r^5}{1\,-\,r^5}\right)^{1/2}\,,$$
$$X = r\,.$$

- UV regime: locally AdS_7 with $X = 1$ and $\mathcal{F}_{(4)\,0123} = \mathcal{F}_{(4)\,3456} = 0\,.$
- IR regime: Generic singularity. We want to give the physical interpretation of this singularity!

$\mathrm{AdS}_7/\mathrm{CFT}_6$ in Massive IIA

- Massive type IIA with $\mathrm{AdS}_7 \times_w \tilde{S}^3$ vacuum $\rightarrow \mathcal{N} = 1$ minimal gauged supergravity in $d = 7$. [Apruzzi, Fazzi, Rosa, Tomasiello. 2013.] [Passias, Rota, Tomasiello. 2015.].

- Branes' intersection NS5-D6-D8. [Hanany, Zaffaroni. 1998.] [Imamura. 2001].

- $\mathrm{AdS}_7 \times_w \tilde{S}^3$ "near-horizon" of NS5-D6-D8 with 16 supercharges. [Gaiotto, Tomasiello. 2014.] [Bobev, Dibitetto, Gautason, Truijen. 2016.].

- Non-lagrangian theory arising as the fixed point of the 6d worldvolume QFT. [Hanany, Zaffaroni. 1998.].

- Dual to $\mathcal{N} = (1, 0)$ SCFT_6. [Gaiotto, Tomasiello. 2014.].

AdS_3 Slicing and its Massive IIA Interpretation

- In the UV the solution is dual to the $\mathcal{N} = (1, 0)$ SCFT_6: it describes the near-horizon of NS5-D6-D8.
- What happens in the IR? The singular behavior and the dyonic profile of $\mathcal{F}_{(4)}$ in $d = 7$ hints the presence of D2 and D4-branes filling the AdS_3 and intersecting the bound state NS5-D6-D8!

branes	t	y	ρ	φ^1	φ^2	φ^3	z	r	θ^1	θ^2
NS5	×	×	×	×	×	×	—	—	—	—
D6	×	×	×	×	×	×	×	—	—	—
D8	×	×	×	×	×	×	—	×	×	×
D2	×	×	—	—	—	—	×	—	—	—
D4	×	×	—	—	—	—	—	×	×	×

The Brane Picture of D2-D4-NS5-D6-D8

- Imamura solution for NS5-D6-D8 $\to S(r,z),\ K(r,z)$. [Imamura. 2001].
- "Non-standard" intersection with D2-D4.

  (see [Boonstra, Peeters, Skenderis. 1998.]).

$$
\begin{aligned}
ds_{10}^2 &= S^{-1/2} H_{\rm D2}^{-1/2} H_{\rm D4}^{-1/2}\, ds^2_{\mathbb{R}^{1,1}} + S^{-1/2} H_{\rm D2}^{1/2} H_{\rm D4}^{1/2} \left(d\rho^2 + \rho^2\, ds^2_{S^3}\right) \\
&+ K\, S^{-1/2} H_{\rm D2}^{-1/2} H_{\rm D4}^{1/2}\, dz^2 + K\, S^{1/2} H_{\rm D2}^{1/2} H_{\rm D4}^{-1/2} \left(dr^2 + r^2\, ds^2_{S^2}\right) , \\
e^{\Phi} &= g_s\, K^{1/2}\, S^{-3/4} H_{\rm D2}^{1/4} H_{\rm D4}^{-1/4} , \\
H_3 &= \frac{\partial}{\partial z}(K S)\, \mathrm{vol}_3 - dz \wedge \star_3\, dK , \qquad F_0 = m , \qquad F_2 = -g_s^{-1} \star_3 dS \\
F_{(4)} &= g_s^{-1}\, \mathrm{vol}_{\mathbb{R}^{1,1}} \wedge dz \wedge dH_{\rm D2}^{-1} + \star_{10} \left(\mathrm{vol}_{\mathbb{R}^{1,1}} \wedge \mathrm{vol}_3 \wedge dH_{\rm D4}^{-1}\right) ,
\end{aligned}
$$

where $\quad m g_s\, K - \frac{\partial S}{\partial z} = 0 , \quad r^{-2}\, \partial_r (r^2 \partial_r\, S) + \frac{1}{2} \frac{\partial^2}{\partial z^2} S^2 = 0 ,$

$$
H_{\rm D2}(\rho, r) = \left(1 + \frac{Q_{\rm D4}}{\rho^2}\right)\left(1 + \frac{Q_{\rm D6}}{r}\right) , \quad H_{\rm D4}(\rho) = \left(1 + \frac{Q_{\rm D4}}{\rho^2}\right) .
$$

The Near-Horizon

- Near-horizon: $z, r \to \infty$ with $\frac{r}{z^2}$ finite.
- Far from the defect $\rho \to \infty$ (i.e. $H_{\mathrm{D4}} \to 1$ and $H_{\mathrm{D2}} \to H_{\mathrm{D6}}$):

$$\mathrm{d}s^2_{10} \sim 2\cos\alpha \left(\tan\alpha\,\mathrm{d}s^2_{\mathrm{AdS}_7} + \tan\alpha\,\mathrm{d}\alpha^2 + \frac{1}{4}\sin^2\alpha\,\mathrm{d}s^2_{S^2}\right) .$$

$\Longrightarrow \mathrm{AdS}_7 \times_w \tilde{S}^3 \longleftrightarrow \mathcal{N} = (1,0)\ \mathrm{SCFT}_6$.

- Zooming on the defect $\rho \to 0 \to$ warped $\mathrm{AdS}_3 \times I_\zeta \times S^3 \times I_\alpha \times S^2$ with 7d part:

$$ds^2_7 \sim \zeta^{-1/4} \underbrace{\left(\frac{\rho^2}{Q_{\mathrm{D4}}}\,\mathrm{d}s^2_{\mathbb{R}^{1,1}} + \frac{Q_{\mathrm{D4}}}{\rho^2}\,d\rho^2\right)}_{\mathrm{d}s^2_{\mathrm{AdS}_3}} + \frac{d\zeta^2}{\zeta^2} + Q_{\mathrm{D4}}\,\zeta^{-1/4}\,\mathrm{d}s^2_{S^3} ,$$

$\Longrightarrow$ this is our 7d CDW! $\longleftrightarrow$ defect $\mathcal{N} = (4,0)\ \mathrm{SCFT}_2$