New AdS/CFT duals through non-Abelian T-duality

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Motivation:

- Non-Abelian T-duality (NATD) very useful in generating new supergravity backgrounds with CFT duals
  (Sfetsos, Thompson'10)

- Interesting relations between AdS backgrounds

$AdS_5 \times S^5$ — NATD → Uplift to 11 dim — Gaiotto & Maldacena geometries (dual to Gaiotto's N=2 SCFTs)

$AdS_5 \times T^{1,1}$ — NATD → Uplift to 11 dim — Bah, Beem, Bobev, Wecht sols. (dual to N=1 SCFTs (Sicilian quivers))

(Sfetsos, Thompson'10; Itsios, Nuñez, Sfetsos & Thompson'13)

(This may be so because NATD has not been proved to be a String Theory symmetry, unlike its Abelian counterpart)

In this talk we will use NATD to generate new AdS_6 and AdS_4 backgrounds

AdS_6 : AdS_6 backgrounds are quite unique ("no-go" theorem) (Passias'12)

Dual to 5d fixed point theories with interesting properties, intrinsically strongly coupled, whose ST realization is only known in very specific cases

(Seiberg'96; Intriligator, Morrison, Seiberg'97)

The only known AdS_6 background (before 1212.1043) arises as the near horizon geometry (Brandhuber, Oz'99)

Search for new realizations of 5d fixed point theories by scanning over possible AdS_6 vacua in SUGRA

New AdS_6 background through NATD with SUSY fully preserved (Y.L., O Colgain, Rodriguez-Gomez, Sfetsos, PRL (2013))

Only known background in IIB

(Apruzzi, Fazzi, Passias, Rosa, Tomasiello'14)

NATD as a powerful tool to construct explicit backgrounds unaccessible by other means

New fixed point theory?

(Y.L., O Colgain, Rodriguez-Gomez, JHEP (2014))

AdS_4 : AdS_4 backgrounds associated to wrapped M5-branes are scarce (Gauntlett, Mac Conamhna, Mateos, Waldram'06)

For N=2 they should be dual to the 6d (2,0) CFT's compactified in Σ_3 in 3d-3d duality

The only known explicit solution (before 1408.0912) is the sol. in Pernici, Sezgin'85 (Gabella, Martelli, Passias, Sparks'12)

New N=2 IIB AdS_4 background not in Lüst, Tsimpis'09 through NATD (Y.L., Macpherson, JHEP (2014)) without electric flux (in 11d)

Also in this paper: Proposal for a CFT interpretation of the running to infinity of the non-compact direction generated by NATD

2. Non-Abelian T-duality back in the 90's

Rocek and Verlinde's formulation of Abelian T-duality for ST in a curved background (Rocek, Verlinde'92) :

i) Identify an Abelian isometry: $\theta \to \theta + \epsilon$

ii) Gauge the isometry: $d\theta \to D\theta = d\theta + A$

iii) Add a Lagrange multiplier term: $\tilde{\theta}\, dA$

iv) Integrate the gauge field

$\to$ Dual sigma model with $\{\theta, X^\alpha\} \to \{\tilde{\theta}, X^\alpha\}$ and $(\tilde{g}, \tilde{B}_2, \tilde{\phi})$ given by Buscher's formulae

v) For non-trivial world-sheets:

Invariance under $\oint_\gamma d\epsilon = 2\pi n$ fixes $\oint_\gamma d\tilde{\theta} = 2\pi m$

Same thing in the non-Abelian case: (De la Ossa, Quevedo'93)

i) $X^m \to g^m_n X^n \, , g \in G$

iii) Add a Lagrange multiplier term: $\mathrm{Tr}(\chi F)$

$\to$ Dual sigma model with $\{X^m, X^\alpha\} \to \{\chi^m, X^\alpha\}$

However,

- Non-involutive
- Higher genus generalization? Set to zero $W_\gamma = P\, e^{\oint_\gamma A}$
- Global properties?
- Conformal invariance not proved in general

True symmetry in ST?

NATD as a solution generating technique

(Sfetsos, Thompson'10)

Need to know how the RR fields transform

In the Abelian case: Reduce to a unique N=2, d=9 SUGRA

(Bergshoeff, Hull, Ortín'95)

Hassan'99: Implement the relative twist between left and right movers in the bispinor formed by the RR fields:

$$\hat{P} = P\Omega^{-1} \qquad P = \frac{e^{\phi}}{2}\sum_{k}\frac{1}{k!}F_{\mu_1\ldots\mu_k}\Gamma^{\mu_1\ldots\mu_k}$$

with $\Omega = \sqrt{g_{00}^{-1}}\Gamma_{11}\Gamma^{0}$

Same thing in the non-Abelian case

Interesting AdS solutions have been found

Given that NATD is not guaranteed to be a symmetry of ST:

- Some of the properties of the dual CFT derived from SUGRA may no longer hold after adding corrections on the inverse 't Hooft coupling or in 1/N

- In fact, new CFTs may arise that may only exist in the strong coupling regime

(This seems to be the case with the NATD of $AdS_5 \times S^5$ and $AdS_5 \times T^{1,1}$!)

Explore new (5d and 3d) examples

3. Non-Abelian T-duality and 5d fixed point theories

5d gauge theories are non-renormalizable:

$$[g^2] = M^{-1} \quad \rightarrow \quad g^2 E \quad \rightarrow \quad \text{UV completion}$$

5d SYM with minimal SUSY can be at fixed points for specific gauge groups and matter content

(Seiberg'96; Intriligator, Morrison, Seiberg'97)

- They are intrinsically strongly coupled $\rightarrow AdS/CFT$
- The string theory realization is however only known in very specific cases
- In particular, $Sp(N)$ (with specific matter content) can be realized in Type I' in a D4/D8/O8 system. (Seiberg'96)

  The only known AdS_6 background (before arXiv:1311.4842) arises as the near horizon geometry (Brandhuber, Oz'99)

The Brandhuber-Oz background

Fibration of AdS_6 over half-S^4 with an S^3 boundary at the position of the O8-plane, preserving 16 SUSYs

$$ds^2 = \frac{W^2\,L^2}{4}\left[9\,ds^2(AdS_6) + 4\,ds^2(S^4)\right] \qquad \theta \in [0, \frac{\pi}{2}]$$

$$F_4 = 5\,L^4\,W^{-2}\,\sin^3\theta\,d\theta \wedge \mathrm{Vol}(S^3)$$

$$e^{-\phi} = \frac{3\,L}{2\,W^5}\,, \qquad W = (m\,\cos\theta)^{-\frac{1}{6}} \qquad m = \frac{8 - N_f}{2\pi l_s}$$

The non-Abelian T-dual

- Take the $AdS_6 \times S^4$ background

$$ds^2 = \frac{W^2 L^2}{4}\left[9ds^2(AdS_6) + 4\left(d\theta^2 + \sin^2\theta ds^2(S^3)\right)\right]$$

$$F_4 = 5L^4 W^{-2}\sin^3\theta\, d\theta \wedge \mathrm{Vol}(S^3)$$

- Dualize it w.r.t. one of the $SU(2)$ symmetries

In spherical coordinates adapted to the remaining $SU(2)$:

$$ds^2 = \frac{W^2\, L^2}{4}\left[\,9\, ds^2(AdS_6) + 4\, d\theta^2\,\right] + e^{-2\,A}\, dr^2 + \frac{r^2\, e^{2\,A}}{r^2 + e^{4\,A}}\, ds^2(S^2)$$

$$B_2 = \frac{r^3}{r^2 + e^{4\,A}}\,\mathrm{Vol}(S^2) \qquad e^{-\phi} = \frac{3\,L}{2\,W^5}\, e^{A}\,\sqrt{r^2 + e^{4\,A}}$$

$$F_1 = -G_1 - m\, r\, dr \qquad F_3 = \frac{r^2}{r^2 + e^{4\,A}}\left[-r\, G_1 + m\, e^{4A}\, dr\right] \wedge \mathrm{Vol}(S^2)$$

- It solves the IIB equations of motion
- SUSY preserved! First example of a non-Abelian T-dual geometry with supersymmetry fully preserved

  This is because the internal symmetry is really $SU(2) \times SU(2)_R$ and we dualize on the $SU(2)$ global symmetry *
- What about r ?
  - Background perfectly smooth for all $r \in \mathbb{R}^+$
  - No global properties inferred from the non-Abelian transf.
  - Puzzle to the dual CFT (!)

* NATD and SUSY: Kelekci, Y.L., Macpherson, O Colgain, arXiv:1409.7406

4. Non-Abelian T-duality in ABJM

Take the $AdS_4 \times CP^3$ IIA dual +

parameterize the CP^3 as a foliation in $T^{1,1} = S^2 \times S^3$ +

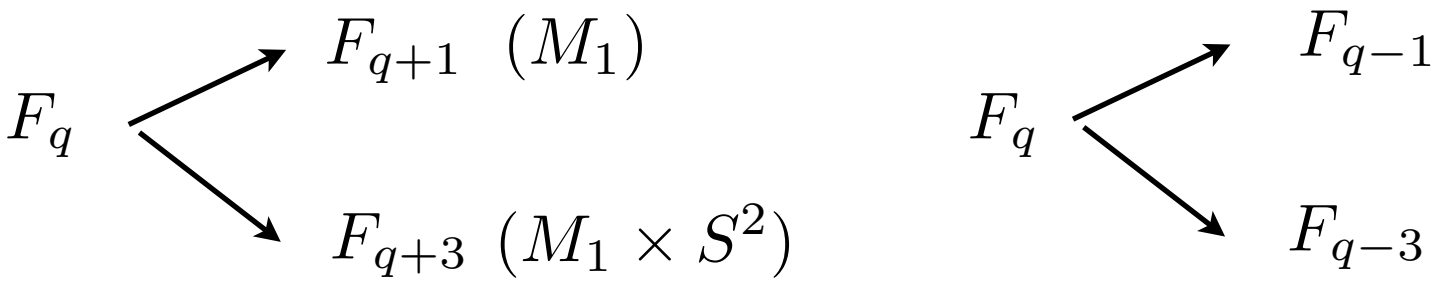
T-dualize w.r.t. the $SU(2)$ symmetry of the S^3

$\longrightarrow$ IIB AdS_4 solution with B_2, F_1, F_3, F_5

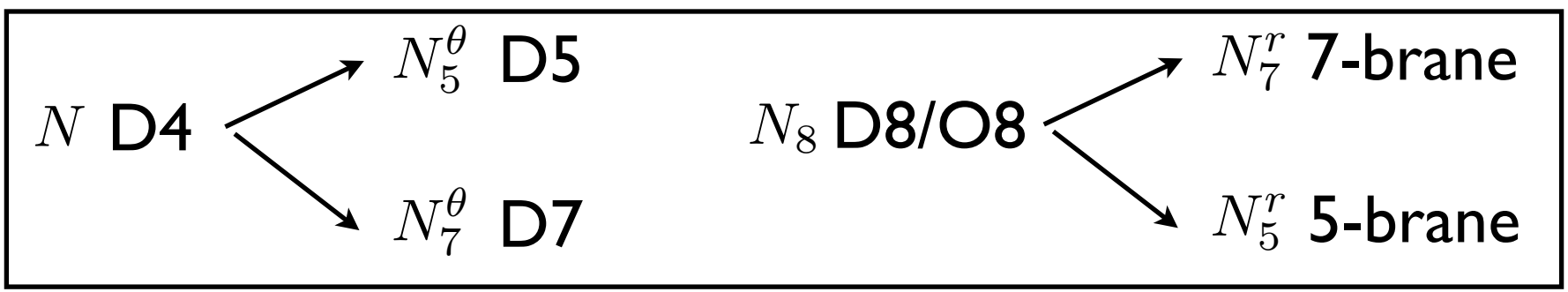
- N=2 supersymmetric
- What about r ?
  - Background perfectly smooth for all $r \in \mathbb{R}^+$
  - No global properties inferred from the non-Abelian transf.
  - Puzzle to the dual CFT (!)

5. Some hints on the dual CFTs

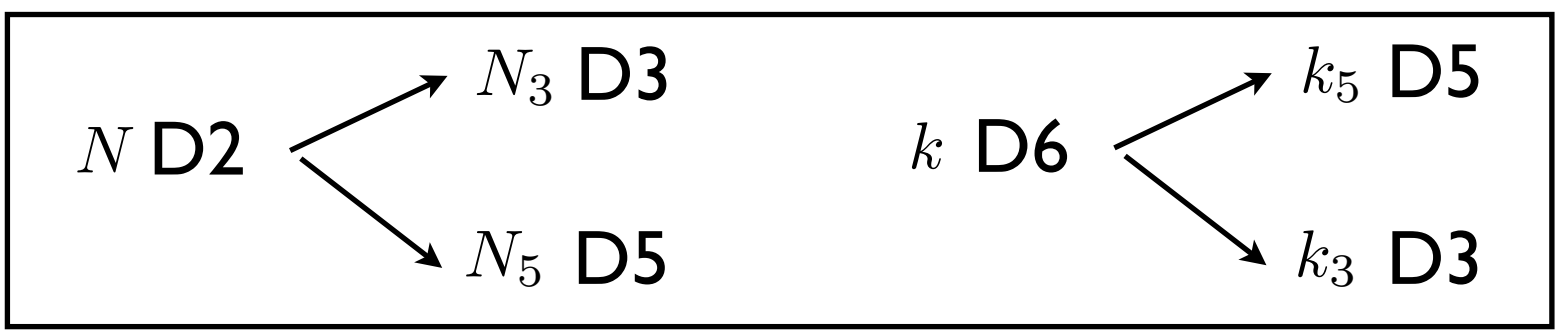
After an $SU(2)$ NATD:



AdS_6



AdS_4



In AdS_6 :

D4 $\longleftrightarrow$ D8 flavor
D0 instanton

D8 flavor
D0 instanton $\longleftrightarrow$ D5 $\longleftrightarrow$ D7 flavor
D1 instanton

D8 flavor
D0 instanton $\longleftrightarrow$ D7 $\longleftrightarrow$ D5 flavor
D3 instanton

Baryon vertex: D4 $\rightarrow$ D1, D3

In AdS_4 :

D6 $\longleftrightarrow$ D2 level

D2 level $\longleftrightarrow$ D3 $\longleftrightarrow$ D5 level

D2 level $\longleftrightarrow$ D5 $\longleftrightarrow$ D3 level

D6 baryon vertex $\rightarrow$ D5, D3

D2 ‘t Hooft monopole $\rightarrow$ D3, D5

...

CFT interpretation?

Look at large gauge transformations:

Close to the singularity the geometry is conformal to a singular cone with S^2 boundary, where $B_2 = r\,\mathrm{Vol}(S^2)$

Large gauge transformations must be defined such that

$$\frac{1}{4\pi^2}\left|\int B_2\right| \in [0,1) \quad \text{for} \quad r > \pi \qquad \Rightarrow$$

We need $B_2 = (r - n\pi)\,\mathrm{Vol}(S^2)$ for $r \in [n\pi, (n+1)\pi)$

This modifies the Page charges, such that $N_{p-2} = n\,N_p$

$\Rightarrow$ Moving from an $r \in [n\pi, (n+1)\pi)$ interval to the previous one: $N_{p-2} \to N_{p-2} - N_p$

Reminiscent of Seiberg duality

But same CFT!

- In the 5d case:

Moving from an r interval to the previous one:

$$N_5^\theta \to N_5^\theta - N_7^\theta$$

This suggests a dual CFT with gauge group, as r varies:

$$Sp(N_5^\theta + N_7^\theta) \times Sp(N_5^\theta)$$

For $r \in [0, \pi)$ the CFT would be $Sp(N_7^\theta)$.

$\to$ Fixed point theory from 7-branes?

(DeWolfe, Hanany, Iqbal, Katz' 99)

- In 3d the same idea suggests a dual CFT:

$$U(N_3 + N_5)_{k_3} \times U(N_3)_{k_5} \times U(N_3 + N_5)_{-k_3} \times U(N_3)_{-k_5}$$

For $r \in [0, \pi)$: $U(N_5)_{k_3} \times U(N_5)_{-k_3}$

$\to$ N=2 CFT generated by D5-branes?

What happens as we move in r?

Invariance of ST under large gauge transformations suggests that the dual CFTs could be related by some duality

If this is true, in 5d all CFT would be equivalent to the one dual to the solution for $r \in [0, \pi)$: $Sp(N_7^\theta)$ with N_5^r flavors

New fixed points associated with product gauge groups ruled out in the classification of Intriligator, Morrison, Seiberg

Same idea in 3d: D5-color branes with D3 "level" branes, N=2

But, we are moving in an internal direction, not in the holographic direction!

A comment about the free energies

5d: In the original theory: $F \sim \frac{N^{5/2}}{m^{1/2}}$ (Jafferis, Pufu'12)

In the dual: $F \sim \frac{(N_7^\theta)^{5/2}}{(N_5^r)^{1/2}}$

3d: In the original theory: $F(S^3) \sim \sqrt{k}\, N^{3/2}$

(Drukker, Mariño, Putrov'10)

In the dual: $F(S^3) \sim \sqrt{k_3}\, N_5^{3/2}$

But the proportionality factors depend on n for the various $[n\pi, (n+1)\pi)$ intervals. Duality?

New suggestion in Bea, Edelstein, Itsios, Kooner, Núñez, Schofield, Sierra-García'15 (see conclusions)

6. Conclusions

- NATD useful as a solution generating technique:

  New AdS_6 and AdS_4 backgrounds

- First steps towards a systematic study of the dual CFTs

  Realization in the CFT of the running of the non-compact direction: very similar to the cascade, but on the internal direction

  Can the CFTs dual to the solution as r varies be equivalent?

  The internal volume changes $\Rightarrow$ Different free energies

  Proposal by Santiago-Swansea group: Motion in r induces D(p-2) charge $\Rightarrow$ New gauge groups through "un-Higgsing"

  Where is the energy scale?

Thanks!