A new infinite class of AdS flux vacua

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Introduction

This talk is about supersymmetric AdS vacua.

- We don’t live in AdS$_4$; nor is supersymmetry unbroken

**But:** Useful first step. Several ideas to then ‘lift’ to dS$_4$ eg [KKLT’03]

(⟺ susy breaking)

- ‘Generalized complex geometry’ suggested rich structure of vacua beyond Calabi-Yau’s

[Graña,Minasian,Petrini,AT’05,’06]
● In this talk, we will start vindicating that expectation:

IIA vacua in $\text{AdS}_4 \times \mathbb{CP}^3$ [AT’07]

a rich ‘discretuum’
of vacua
with same topology

$N = 1$

old solution;
$N = 6$

● Recently: CFT3 duals with lagrangian description [Aharony,Bergman,Jafferis,Maldacena ’08…]

can we now proceed to lower supersymmetry?

yes: we will see $N = 3$ quivers [Jafferis,AT’08] using ‘hypertoric geometry’

Plan

● Overview of $\text{AdS}_4$ vacua

the role of the ‘Romans mass’

● Old solutions in new perspective

the recurrence of $\mathbb{CP}^3$

● New solutions

and conjectures
Overview of AdS4 vacua (in IIA)

Internal manifold: ‘generalized half-flat’

[for Minkowski vacua: ‘generalized complex’]

All known* vacua belong to ‘SU(3) structure’ class

\[ \text{in which case, geometry:} \]

\[ dJ \propto \text{Re} \Omega \]
\[ \Delta \text{Re} \Omega \propto \text{Re} \Omega \]
\[ J \wedge \Omega = 0 \]
\[ \Omega \wedge \overline{\Omega} = iJ^3 \]

*‘nontrivial’

The master of all fluxes is \( F_0 \) (“Romans mass”) many more vacua!

\[
\begin{array}{|c|c|}
\hline
F_0 = 0 & F_0 \neq 0 \\
\hline
\mathcal{N} > 1 \text{ possible} & \mathcal{N} > 1 \text{ impossible} \\
\hline
\text{dilaton can vary} & \text{dilaton is constant} \\
\hline
\exists \text{ M-theory lift} & \nexists \text{ M-theory lift} \\
\hline
\text{near-horizon limits} & \text{not so far} \\
\hline
\end{array}
\]

[for ‘SU(3) structure’ class]
We can say more by introducing \( \sin(\theta) \sim \frac{F_0}{\sqrt{-\Lambda}} \), where cosmological constant \( \Lambda \) is.

\[ F_0, F_4, H \propto \sin(\theta) \]

\[ F_2, F_6 \propto \cos(\theta) \]

\( F_k \) are internal fluxes; \( k \) are internal fluxes.

\[ \theta \] are internal fluxes.

\[ \text{this limit can be violated with magnetic sources; eg } [\text{deWolfe, Giryavets, Kachru, Taylor '05}] \]

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**Old solutions in new perspective**

- \( \theta = 0 \)
  - \( F_0 = 0 \)
  - \( F_2 \neq 0 \)

Example:

\[ \text{AdS}_4 \times S^7 \quad (N = 8) \]

\[ \text{AdS}_4 \times \mathbb{CP}^3 \quad (N = 6) \]

\[ [\text{Nilsson, Pope '84}; \text{Watamura '84}; \text{Sorokin, Tkach, Volkov '85}] \]

Fubini-Study

Kähler; but didn’t we say \( dJ \propto \text{Re}\Omega \)?

Different (almost) complex structures
many more examples of the same type:

[be careful not to lose susy when reducing to IIA]

| $\mathcal{N} = 3$ | hyperKähler | $\text{SU}(3)/U(1) \left\{ \frac{U(1)}{U(1)} \right\}$ (S(Ω)) |
| $\mathcal{N} = 2$ | Calabi-Yau  | $\left( \frac{\text{SU}(2)}{U(1)} \right)^3$ ; “YP, k” |
| $\mathcal{N} = 1$ | Spin(7) hol. | squashed $S^7$ ; $\text{SU}(3)/U(1)$ |

Chern-Simons-matter duals: [Jafferis, AT’08]

quivers

other dualities proposed in
[Ahn ’08, Benna, Klebanov, Klose, Smedbäck ’08, Ooguri, Park ’08…]

$\sin(\theta) = \frac{1}{4}$

‘extremal case’ [Behrndt, Cvetic’04]

all fluxes are on!

coincidence*: condition on $M_6$ is

\( (\text{nearly Kähler}) \)

\( \text{Cone}(M_6) \)

has $G_2$ holonomy

*not explained by a brane near-horizon limit

four cases known explicitly*:

$\text{AdS}_4 \times$:

- $\mathbb{CP}^3$
  - not Fubini-Study!
  - but still Einstein
- $\text{SU}(3)/U(1) \times U(1)$
- $S^3 \times S^3$
- $S^6$

we saw these two topologies already for $\theta = 0$

...but with different metrics

*with isolated singularity
New vacua

We have seen three vacua on $\text{AdS}_4 \times \mathbb{CP}^3$

These are three different metrics.

$\mathbb{CP}^3$ is a sphere fibration:

\[ ds^2 = R^2 (g_{ij} (dx^i + A^i) (dx^j + A^j) + \sigma dS^2_{S^4}) \]

those three metrics on $\mathbb{CP}^3$ are:

- the whole segment allows supergravity solutions
- flux quantization 'fixes moduli'

\[ F_0 = 0 \]
- from $\text{AdS}_4 \times S^7$
- using that $\text{Cone}(\mathbb{CP}^3)$ has $G_2$ holonomy

\[ F_0 \neq 0 \]
- from $\text{AdS}_4 \times \{\text{sq. } S^7\}$

\[ \sigma \]

\[ \text{Fubini-Study} \]

[AT’07]
for each of these $\sigma$, can achieve $R \gg l_s$ and $g_s \ll 1$ parametrically

generically all fluxes are on.
Are these results limited to $\mathbb{CP}^3$?

for ‘flag manifold’ $\frac{\text{SU}(3)}{\text{U}(1)^2}$

[AT’07; Koerber, Lüst, Tsimpis ‘08]

Brane duals to these geometries make one suspect of a more general story.

(Also discretized by flux quantization)

Conclusions

Even in a simple topology, infinitely many supersymmetric vacua

- Infinitely many new Chern-Simons duals ($\mathcal{N} = 3$)