A new infinite class of AdS flux vacua

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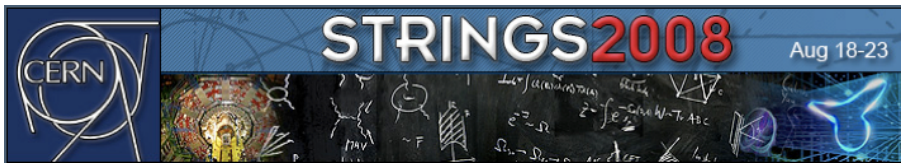


Introduction

This talk is about supersymmetric AdS_4 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]

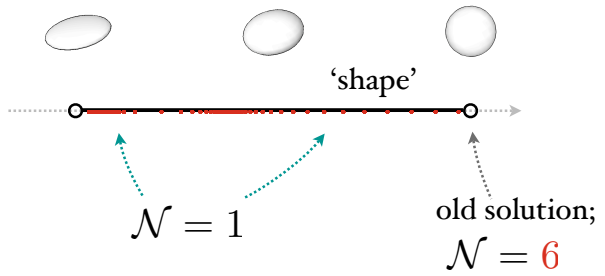
(⇨ susy breaking)

- 'Generalized complex geometry' [Graña,Minasian,Petrini,AT'05,'06]
  suggested rich structure of vacua beyond Calabi-Yau's

- In this talk, we will start vindicating that expectation:

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

a rich 'discretuum' of vacua with same topology



[sample]

- Recently: CFT3 duals with lagrangian description

[Aharony,Bergman,Jafferis,Maldacena '08....]

can we now proceed to lower supersymmetry?

yes: we will see $\mathcal{N} = 3$ quivers using 'hypertoric geometry'

[Jafferis,AT '08]

Plan

- Overview of AdS4 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' [Graña,Minasian,Petrini,AT '06]

[for Minkowski vacua: 'generalized complex'] [Graña,Minasian,Petrini,AT '05]

All known* vacua belong to '$\mathrm{SU}(3)$ structure' class [Lüst,Tsimpis'04]

in which case, geometry:

$$d\boxed{J \propto \mathrm{Re}\Omega}$$

$$\boxed{\Delta\mathrm{Re}\Omega \propto \mathrm{Re}\Omega}$$

$$J \wedge \Omega = 0$$

$$\Omega \wedge \overline{\Omega} = iJ^3$$

*'nontrivial'

The master of all fluxes is F_0 ("Romans mass")

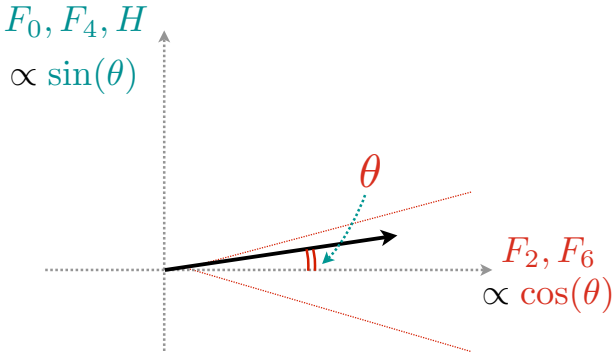
many more vacua!

$F_0 = 0$	$F_0 \neq 0$
$\mathcal{N} > 1$ possible	$\mathcal{N} > 1$ impossible
dilaton can vary	dilaton is constant
$\exists$ M-theory lift	$\nexists$ M-theory lift
near-horizon limits	not so far

[for '$\mathrm{SU}(3)$ structure' class]

We can say more by introducing $\sin(\theta) \sim \dfrac{F_0}{\sqrt{-\Lambda}}$

cosmological constant



[F_k are internal fluxes]

[Lüst,Tsimpis'04]

actually, F_2 has also a term of norm

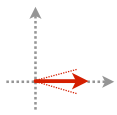
$\propto 1 - 16\sin^2(\theta)$

$\Rightarrow$ $\boxed{|\sin(\theta)| < \dfrac{1}{4}}$

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

Old solutions in new perspective

- $\theta = 0$



$F_0 = 0$

$F_2 \neq 0$

one finds many examples by reduction from M-theory of M2 near-horizon limits

Example: $\mathrm{AdS}_4 \times S^7$ (round) $(\mathcal{N} = 8)$

$\downarrow$

$\mathrm{AdS}_4 \times \mathbb{CP}^3$ (Fubini-Study) $(\mathcal{N} = 6)$

[Nilsson,Pope'84; Watamura'84; Sorokin,Tkach,Volkov'85]

Kähler; but didn't we say $dJ \propto \mathrm{Re}\Omega$?

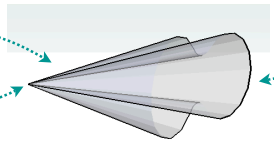
different (almost) complex structures

many more examples of the same type:

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

8d cone

near-horizon limits of M2-branes



7d horizon

$(\mathrm{AdS}_4) \times M_6$

	8d cone	7d horizon (examples)
$\mathcal{N}=3$	hyperKähler	$\frac{\mathrm{SU}(3)}{\mathrm{U}(1)}$; $\mathrm{U}(1)\backslash\mathrm{U}(3)/\mathrm{U}(1)$; "$\mathcal{S}(\Omega)$"
$\mathcal{N}=2$	Calabi-Yau	$\frac{(\mathrm{SU}(2))^3}{(\mathrm{U}(1))^2}$; "$Y^{p,k}$"
$\mathcal{N}=1$	$\mathrm{Spin}(7)$ hol.	squashed S^7 ; $\frac{\mathrm{SU}(3)}{\mathrm{U}(1)}$;

[Aloff,Wallach '75, Castellani,Romans'83]

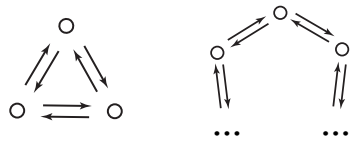
[Eschenburg '82; Boyer,Galicki,Mann'93,'94]

[D'Auria,Fre',Van Nieuwenhuizen '84]

[Martelli,Sparks'08] [Awada,Duff,Pope '83]

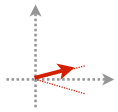
Chern-Simons-matter duals: [Jafferis,AT'08]

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 ('nearly Kähler')

$\mathrm{Cone}(M_6)$ has G_2 holonomy

*not explained by a brane near-horizon limit

four cases known explicitly*: [Bryant,Salamon'89; Gibbons,Page,Pope'90]

$\mathrm{AdS}_4\times$:	$\mathbb{CP}^3$ not Fubini-Study! but still Einstein	$\frac{\mathrm{SU}(3)}{\mathrm{U}(1)\times\mathrm{U}(1)}$	$S^3\times S^3$	S^6

[Villadoro,Zwirner '05; Cámara,Font,Ibañez '05; Aldazabal,Font '07]

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

...but with different metrics

*with isolated singularity

New vacua

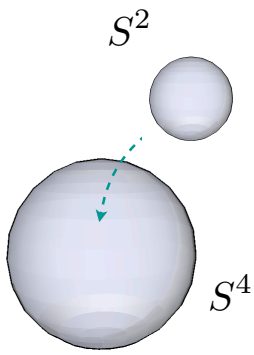
We have seen three vacua on $\mathrm{AdS}_4 \times \mathbb{CP}^3$

$F_0 = 0$
- from $\mathrm{AdS}_4 \times S^7$
- from $\mathrm{AdS}_4 \times \{\text{sq. } S^7\}$

$F_0 \neq 0$
- using that $\mathrm{Cone}(\mathbb{CP}^3)$ has G_2 holonomy

These are three different metrics.

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



overall size

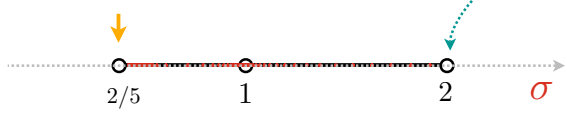
S^2

fibration is nontrivial

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

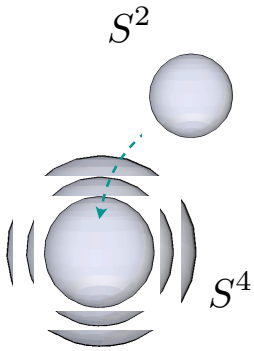
those three metrics on $\mathbb{CP}^3$ are:

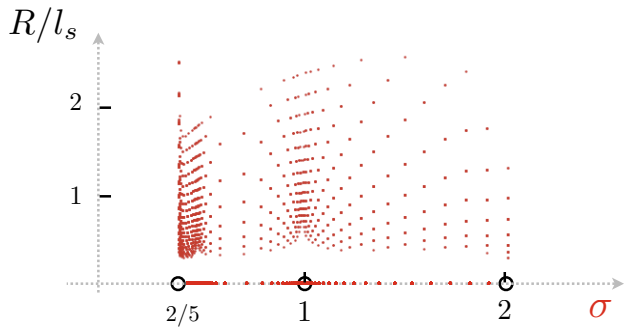
Fubini-Study



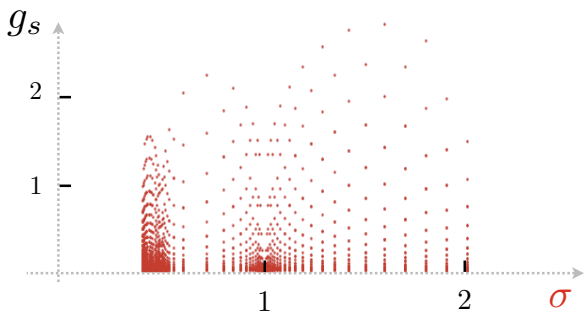
[AT '07]

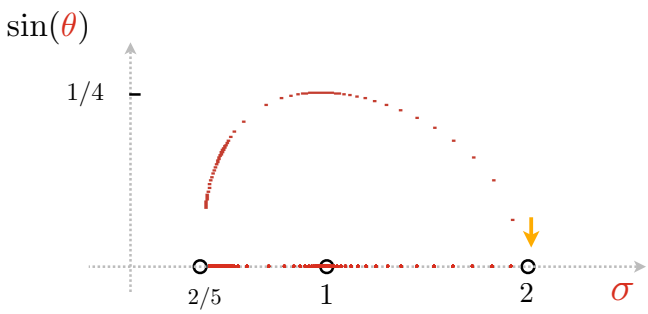
- the whole segment allows supergravity solutions
- flux quantization 'fixes moduli'

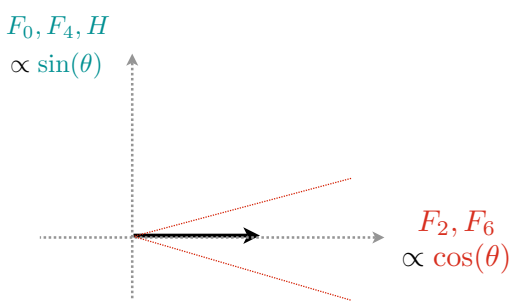




- for each of these σ s, can achieve $R \gg l_s$ and $g_s \ll 1$ parametrically





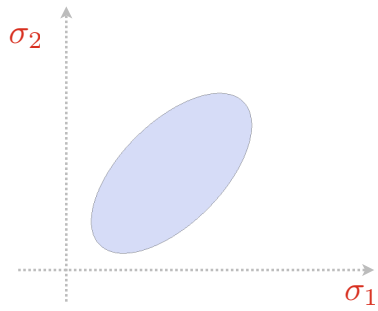


generically all fluxes are on.

Are these results limited to $\mathbb{CP}^3$?

for 'flag manifold' $\dfrac{\mathrm{SU}(3)}{\mathrm{U}(1)^2}$

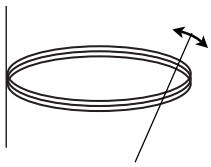
[AT '07; Koerber, Lüst, Tsimpis '08]



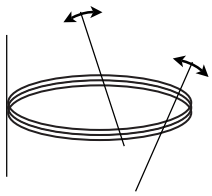
(also discretized by flux quantization)

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

$\mathbb{CP}^3$



$\dfrac{\mathrm{SU}(3)}{\mathrm{U}(1)^2}$



... ?

Conclusions

- Even in a simple topology,
  infinitely many supersymmetric vacua

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