

Non - Spherical Horizons

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Work in progress, with R. Plesser +
E. Silverstein

related work in progress: I. Klebanov + E. Witten

will also discuss:

P. Aspinwall + D.R.M., hep-th/9705104

other related work:

A. Kehagias, hep-th/9805131

O. Aharony, A. Fayyazuddin, J. Maldacena, hep-th/9806159

(1)

In M/string compactification,
several known models require
spacetime-filling branes as
part of the background:

- M-theory models in $2+1$ dim
require $\frac{\kappa}{24}$ M2-branes (tadpole)
- F-theory models in $3+1$ dim
require D3-branes (in addition to
the usual D7-branes)
- Hořava-Witten description of $\text{Het}_{E_8 \times E_8}$ on $K3$
allows M5-branes to move off HW9-brane

From SUGRA viewpoint,
these are included via a
warping factor for metric:

$$\text{Spacetime} = \text{Minkowski} \times \text{Internal}$$

$$\text{metric} = f^{-a} dx_M^2 + f^b dx_I^2$$

$$\text{field strength} = dx_M^{\dim M} \wedge df^{-1}$$

$$\text{EOM} : \Delta f = \delta(x-x_0) + \text{other}$$

	(a, b)
M2	($\frac{2}{3}, \frac{1}{3}$)
D3	($\frac{1}{2}, \frac{1}{2}$)
M5	($\frac{1}{3}, \frac{2}{3}$)

Bring N branes together,
take decoupling limit -
reproduce Maldacena's story
("original" metric doesn't
matter).



In all 3 cases, varying
parameters for I leads to
singularities (at finite distance)
with interesting physics.
"Canonical" singularities.

Question: What happens if we put N branes on a singular point and then take decoupling limit?

Nicest possible answer: Near-horizon geometry becomes

$$AdS^k \times M^{\ell}$$

where $M^{\ell} = \{ \text{points at unit distance from branes} \}$

is no longer a sphere.

Difficulty: We do not know how to analyze singular limits of Ricci-flat metrics.

Caution: If the singularity is not isolated, the induced metric on H^2 has singularities.

Program

- 1) Classify singularities which occur
- 2) Study SUGRA metrics near them
- 3) If possible, find another description of the boundary (FT).

Note: R-symmetries act as isometries on H^2 .

Examples (M2)

- CY 4-fold locally

$$s^2 + t^2 + x^2 + y^3 + z^5 = 0$$

Then H^7 is an exotic 7-sphere.*

(Studied in SUGRA long ago.)

- CY 4-fold locally

$$\mathbb{C}^4 / \mathbb{Z}_2$$

Then $H^7 = S^7 / \mathbb{Z}_2 = \mathbb{R}P^7$

- CY 4-fold singularities hard to classify

* Shubert's theorem

M5 branes

$$I = S^1/\mathbb{Z}_2 \times K3.$$

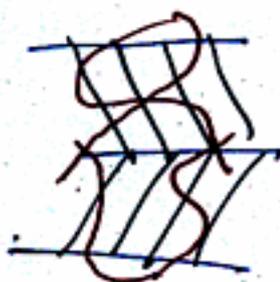
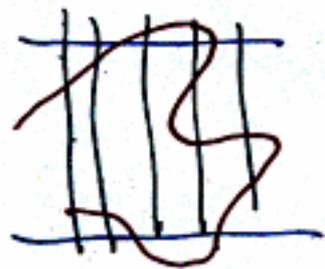
Singularities: ADE on $K3$.

Non-isolated, so SUGRA is incomplete.

Prescription: put all branes at one point of I (at a singular point).

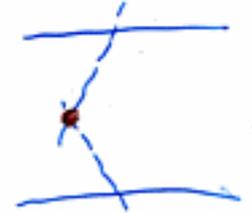
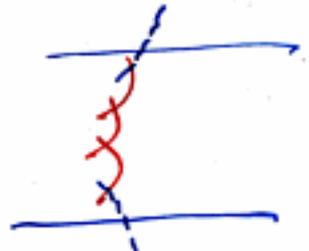
(Other proposals in literature used different points in S^1/\mathbb{Z}_2 direction).

Solved via F-theory dual:



Aspinwall, DRM hep-th/9705109

Intriligator hep-th/9708117



k branes at A_{m-1} :

k tensors and

$$G = U(1) \oplus U(2) \oplus \dots \oplus U(m) \oplus \underbrace{\dots \oplus U(m)}_{k-2m+1} \oplus U(m-1) \oplus \dots \oplus U(1)$$

(bifundamental)

$(D_m, E_6, E_7, E_8 \text{ in paper})$

Still to do : branes at HW9 (Berkovits)

D3 branes

orbifolds: Kehrer-Silverstein
Lawrence-Nekrasov-Vafa
et al. (9)

Canonical singularities in complex dim 3 (incomplete)

- $\mathcal{N}=2$ • curve to point (conifold)
- $\mathcal{N}=2$ • surface to curve (\mathbb{Z}_2 orbifold;
III X III)
- $\mathcal{N}=1$ • surface to point (cone over del Pezzo surface, including \mathbb{Z}_3 orbifold)

• $H^5 = S^2 \times S^3$ for conifold.

Space is a cone on H^5 , well-suited for SUSYM.

To find the CFT, use $\mathbb{Z}_2 \times \mathbb{Z}_2$ orbifold + the partial resolution as described in Greene's talk.

Orbifolds

k branes at A_{m-1}

$$G = U(k)^m$$



Surface \rightarrow pt

$H^5 = S^1$ -bundle over del Pezzo

1) $\mathbb{C}P^2$ $H^5 = S^5/\mathbb{Z}_3$ (no f.p.)

2) $\mathbb{C}P^1 \times \mathbb{C}P^1$ $H^5 = S^2 \times S^3/\mathbb{Z}_2$ (no f.p.)

3) $B\mathbb{P}_{p_1, \dots, p_k} \mathbb{C}P^2$ $H^5 = S^1$ -bundle over S
 \parallel
 S

Einstein metric?