Antibranes in AdS

Friðrik Freyr Gautason

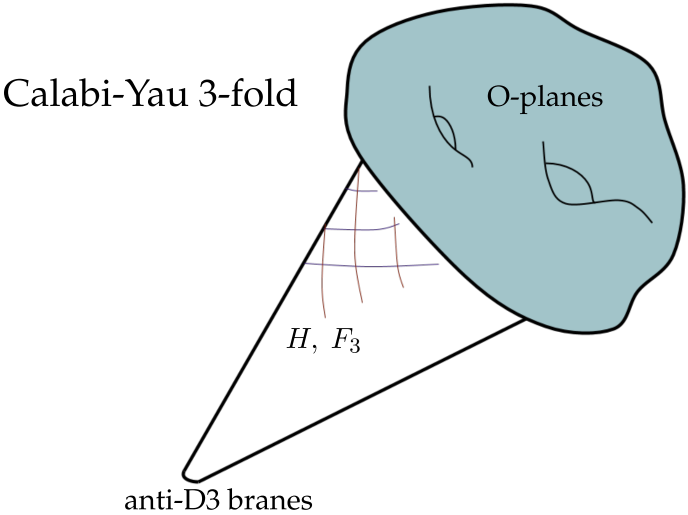
based on arXiv:1502.00927 with Brecht Truijen and Thomas Van Riet

KU LEUVEN

$$\Lambda > 0$$

The KKLT scenario

Giddings, Kachru, Polchinski (2002)
Kachru, Kallosh, Linde, Trivedi (2003)



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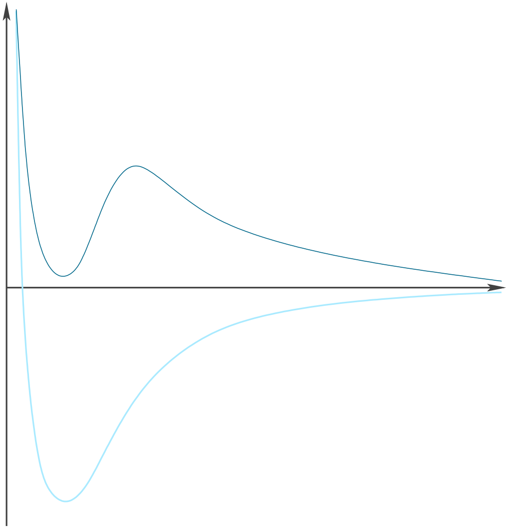

Antibranes preliminary

Antibrane refers to a D-brane which has opposite charge to the surrounding flux

$$\mathrm{d}F_{8-p} = H \wedge F_{6-p} + Q\delta_p \ .$$

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- Compact solutions without orientifolds $\Rightarrow$ AdS. The CC is determined by fluxes.
- Non-compact that can be made compact by cancelling flux energy against O-plane energy so that CC is decoupled from fluxes and branes (GKP style).

Antibrane singularity

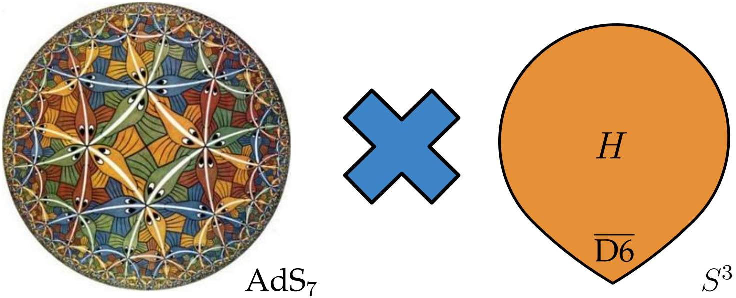
In both cases the backreaction of the antibranes leads to divergence in the flux energy density

$$e^{\phi}|H|^2 \to \infty \,.$$

Bena, Blåbäck, Danielsson, FFG, Graña, Halmagyi, Junghans, Kuperstein, Massai, McGuirk, Shiu, Sumitomo, Van Riet, Wrase, Zagermann, . . .

TOY MODEL FOR ANTIBRANES

Massive type IIA with H-flux and $\overline{\mathrm{D6}}$ branes.



Blåbäck, Danielsson, Junghans, Van Riet, Wrase, Zagermann (2011)
Apruzzi, Fazzi, Rosa, Tomasiello (2014)

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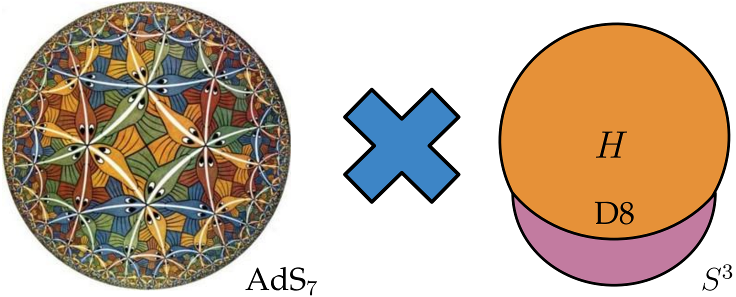

The AdS$_7$ solutions regulate the singularity via brane polarisation (Myers effect).

Apruzzi, Fazzi, Rosa, Tomasiello (2014)
Junghans, Schmidt, Zagermann (2014)
Gaiotto, Tomasiello (2014)

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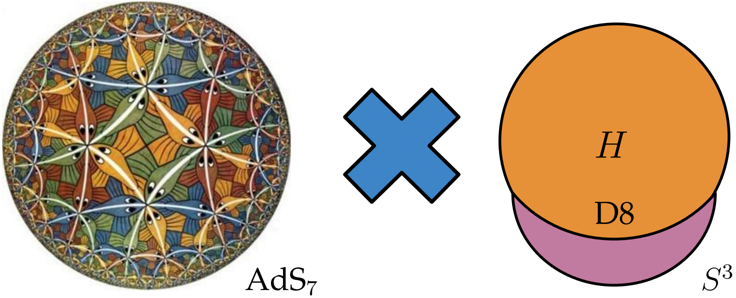

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Bena, Junghans, Kuperstein, Van Riet, Wrase, Zagermann (2012)

Brane-flux decay

What happens to the flat solution that are not regularised via brane polarisation?

Reasonable to assume that the branes will annihilate against the flux.

Danielsson, Van Riet (2014)

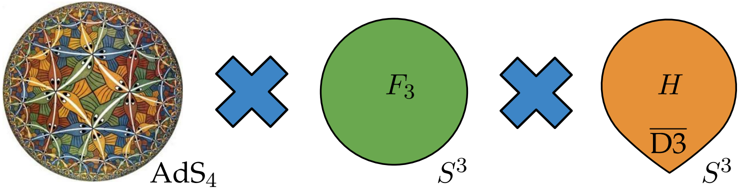
But the decay process is only known microscopically for $\overline{\text{D3}}$ branes.

Kachru, Pearson, Verlinde (2002)

Setup

FFG, Truijen, Van Riet (2015)

Type IIB supergravity with F_3 and H flux together with smeared $\overline{\mathrm{D3}}$ branes



$$\mathrm{d}s^2 = \mathrm{e}^{2A(\rho)}\mathrm{d}s^2_{\mathrm{AdS}_4} + \mathrm{e}^{2B(\rho)}\mathrm{d}\Omega_3^2 + \mathrm{e}^{2C(\rho)}\left(\mathrm{d}\rho^2 + \mathrm{e}^{2D(\rho)}\mathrm{d}\Omega_2^2\right) ,$$

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Fluxes

$$\begin{aligned} H &= -\lambda(\rho)\mathrm{e}^{\phi(\rho)} \star_6 F_3 \, , \\ F_3 &= M \, \mathrm{vol}_3 \, , \\ F_5 &= \mathrm{e}^{-4A} \star_6 \mathrm{d}\alpha(\rho). \end{aligned}$$

The H-equation demands

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$\overline{\text{D3}}$ branes, spacetime filling, localised at $\rho = 0$ and smeared over the S^3.

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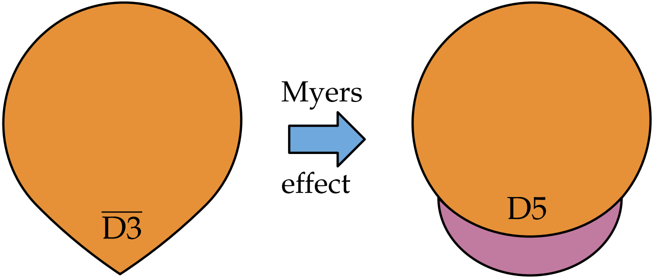
Analogous arguments can be used for the non-compact solution.

Blåbäck, Danielsson, Junghans, Van Riet, Vargas (2014)

Polarization to D5-branes

The singularity suggest that the antibrane wants to polarize to a 5-brane.



Polarization to D5-branes

The singularity suggest that the antibrane wants to polarize to a 5-brane. Consider first the D5-brane, calculate the probe potential by evaluating the D5 action in the background:

$$S_{\mathrm{D5}} = \mu_5 \int \left\{ -\mathrm{e}^{-\phi} \sqrt{-\det(\mathrm{e}^{\phi/2} G - \mathcal{F})} - C_6 + \mathcal{F} \wedge C_4 \right\} .$$

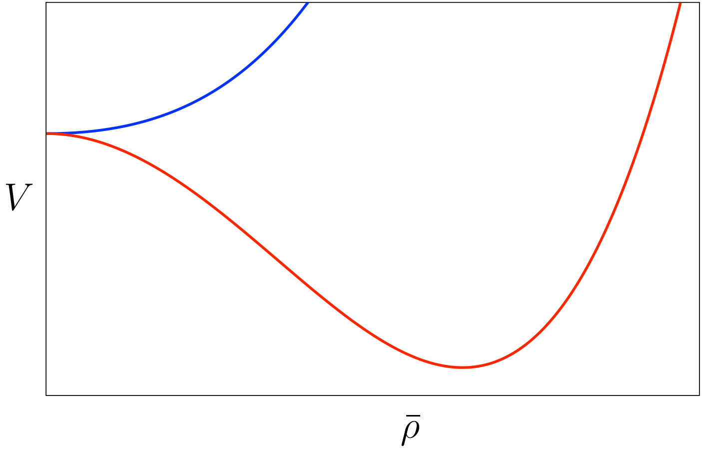
Use the standard flat-brane boundary conditions for the warp factors together with GKP-like equation

$$\nabla^2 L_{\overline{\mathrm{D3}}} - \mathrm{e}^{-4A} \left(\nabla L_{\overline{\mathrm{D3}}} \right)^2 = \mathrm{e}^{4A} \left[4\Lambda \mathrm{e}^{-2A} + \frac{(1+\lambda)^2}{2} \mathrm{e}^{\phi} |F_3|^2 \right] ,$$

where $L_{\overline{\mathrm{D3}}} = \overline{\mathrm{D3}}$ lagrangian $= \mathrm{e}^{4A} + (\alpha - \alpha_0)$. Then expand close to the brane $\rho = 0$.

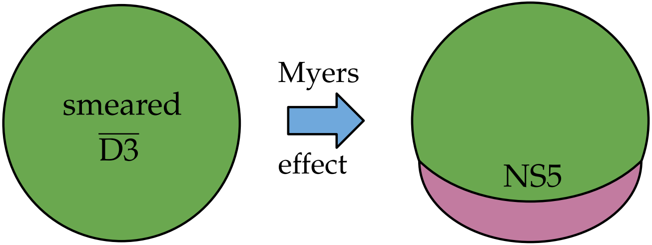
Polarization to D5-branes

$$V \propto \left(8\Lambda + k_0^2\right)\bar{\rho}^2 - 4k_0\bar{\rho}^3 + 6\bar{\rho}^4 + \cdots$$



Polarization to NS5-branes

Similar resolution of the singularity could happen through polarisation into spherical NS5 brane:



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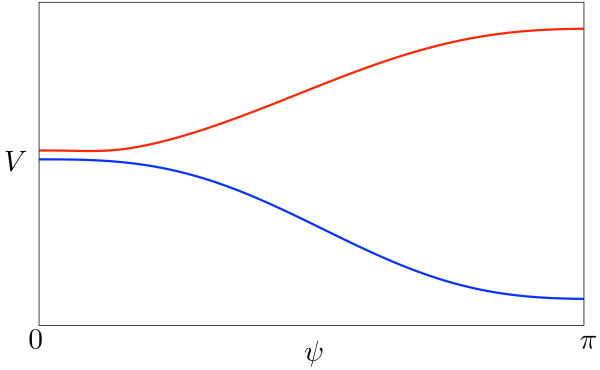
The NS5 wraps a S^2 inside the sphere which the $\overline{\mathrm{D3}}$ branes are smeared. The calculation is even simpler here and follows the one done by KPV. Remember that the NS5 polarisation also serves as a decay channel for *flux* to annihilate against *branes*.

Kachru, Pearson, Verlinde (2002)

Polarization to NS5-branes

$$V \quad \propto \quad \mathrm{e}^{4A}\sqrt{\frac{1}{M^2}\mathrm{e}^{4B-\phi}\sin^4\psi + \frac{1}{4}\left(2\pi\frac{p}{M} - \psi + \frac{1}{2}\sin(2\psi)\right)^2}$$
$$-\frac{\alpha}{2}\left(\psi - \frac{1}{2}\sin(2\psi)\right) - \pi(\alpha-\alpha_0)\frac{p}{M}.$$



Summary

- Antibranes are singular.
- In AdS they are resolved via brane polarisation.
- Flat antibranes, when smeared, annihilate against the surrounding flux.
- Fully localized $\overline{\text{D3}}$ branes might still be OK.

  Hartnett (2015)

- But this contradicts earlier results

  Bena, Buchel, Dias (2013)
  Bena, Graña, Kuperstein, Massai (2013-14)
  Blåbäck, Danielsson, Junghans, Van Riet, Vargas (2014)

- We are currently investigating fully localised $\overline{\text{D3}}$ branes.
- Decay channel of other antibranes is not understood yet, maybe KK-monopoles or non-geometric branes.
- A single flat antibrane may be resolved at string length scales.

  Michel, Mintun, Polchinski, Puhm, Saad (2014)