Observations On Fluxes Near Anti-Branes

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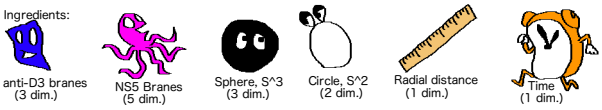
Introduction

- General Relativity (GR) models gravity, fits most of the data. However we don't understand the origin of dark matter and dark energy.
- String Theory is a quantum theory of gravity. We will like to explain with it things that up to now GR can not.

Can we explain dark energy from String Theory?

- Low energy limit of String Theory is Supergravity: it is a ten dimensional geometric theory, it's solution are matter and shapes which interacts.
- One of this shapes are called branes. The branes can have different dimensions and it can come with electric an magnetic fields.



This are the ingredients we will be working with. With them we can build up 10 dimensions line elements (shapes).

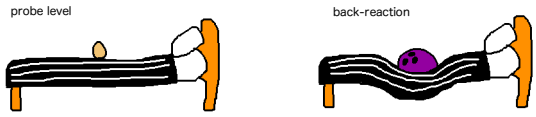
Dark Energy in String Theory: Polarisation

- Kachru, Kallosh, Linde and Trivedi (KKLT) were the first ones to show that there is potentially a way in String Theory to explain dark energy [5]!
- This hinges on "brane polarisation" of anti-D3 branes into a NS5 brane. Kachru, Pearson and Verlinde (KPV) showed that this is in principle possible [6].
- Brane polarisation is a process when a stack of branes, under a background influence, gets transformed into another brane of a bigger dimension.

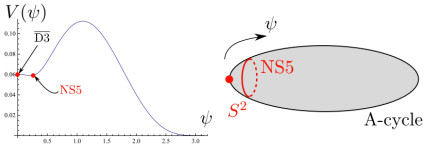
The stack of anti-D3 branes cannot stand each other anymore, so the system prefers to polarise into an NS5 brane that has two directions along the S^3. The blue dots in the NS5 are not only aesthetic: The NS5 will keep with it the anti-D3 charge.

Probe Level and Back-Reaction

- Probe level is the study of a single brane in a fixed background. When we do back reaction, we include how the branes affects its surroundings and vice-versa.



- The KPV research was done at probe level. They found brane polarisation into a NS5 that is metastable in the S^2 at a given radius.



The position of the NS5 in the S^3 it is parametrised with an angle ψ. The potential that the NS5 feels is $V(\psi)$, which has room for a metastable state.

- The construction of this system has been tried beyond the probe level, still in an approximate scheme. There is evidence that the metastable NS5 state shows a bad singularity in the energy density of the H_3 field, [1, 7].

$$e^{-\phi}|H_3|^2 = \infty? \tag{1}$$

In a fully back-reacted picture, does the NS5 still show a bad singularity?

But What Is a Bad Singularity?

- Singularities are common in physics. But we know which kind of singularity correspond to which physical object.

The electric field of an electron stores an infinite amount of energy (singularity), but we know that this is due the presence of an electron (physical object).

$$W \sim \int |\vec{E}|^2 dV = \int \left(\frac{q}{r^2}\right)^2 (r^2 \sin\theta dr d\theta d\phi) \sim \int_0^\infty \frac{1}{r^2} = \infty. \tag{2}$$

- If the singularity and physical object mismatch, we may not have a physical understanding of the singularity.

Our Work: Will We Have Chicken for Dinner?

- We threat the fully back-reacted system but without solving explicitly the equations of motion.
- We will assume that we have (1) a stack of anti-D3 branes or (2) a single NS5 brane. These are our "near boundary conditions".
- Far away, we can measure the mass for (1) and (2), and it will be the same. This will be our "far away boundary condition".
- This will allow us [3] to make claims about the fields and the behaviour of the systems (1) and (2),

$$M = \int_{\partial \mathcal{M}_{IR}} (C_4 \wedge F_5 + B_6 \wedge H_3). \tag{3}$$

This is like imposing what is for dinner: We say that far away it will smell like chicken, close enough it will taste like chicken but... does this mean it will be chicken?

Results: It Might Be Chicken

- In the case of the stack of anti-D3 branes, we will have a bad singularity behaviour.
- In the case of the NS5 branes, we can "cook" the system to get a good singularity behaviour. It is important to say that this does not mean that this solution exists: it only says that if we want a good singularity behaviour for the NS5, there is a very strict recipe to follow.

Anti-D3 brane: Even imposing chicken smell and chicken taste, the outcome will be a chicken soup, not a chicken. NS5: Imposing chicken smell and chicken taste, the output may be a chicken.

The NS5 has the chance to reach a metastable state in which it is free of bad singularities. But we have not prove this scenario exists!

References

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