
About Dark Bubbles

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1 HOW TO INDUCE DARK ENERGY ON A BUBBLE: A SIMPLE EXAMPLE

- Construct the 5D bubble from basic principles. Refer to appendix/chapters where I talk about RS, non-susy, advanced differential geometry and instantons.
- Classic construction. define things static first and then move to radial expansion. Induce positive cosmological constant.
- This can perhaps be a good section to talk about Unruh stuff?

Let us just start with the most basic set-up: A non-supersymmetric Anti-de Sitter vacuum, with cosmological constant $\Lambda_D = -\frac{1}{2}(D-1)(D-2)L^{3-D}$. The parameter L represents the curvature radius of the AdS_D vacuum. For computational convenience, it will be easier to refer to this parameter with its inverse, the vacuum scale $k = \frac{1}{L}$.

As we discussed in section [NON-SUSY], the aforementioned AdS_D vacuum is unstable and will eventually decay to a more metastable solution, via D_p -brane nucleation. This D_p -brane, which is a Coleman-de Luccia/ BT instanton [add ref to CdL and or section], will mediate such decay, separating two different AdS_D vacua. From now on, we will refer to the vacua living inside the hyper-volume encoded by the D_p -brane as the *inside* vacuum, denoted by a minus (-) subscript sign. The tandem brane-inside will be colloquially called *Bubble*. On the other hand, the region *outside* the bubble has not yet decayed, and will be denoted by a positive (+) subscript sign.

Finally, as the aim of this thesis is to discuss phenomenological aspects in four dimensions¹, and given the discussion in [ref to GAUSS-CODAZZI] about co-dimension one hyper-surfaces, we will fix $D = 5$. This implies that the boundary ∂B of the nucleated five-dimensional bubble will have $d = D - 1 = 4$ dimensions.

In this specific scenario, the geometry inside and outside the bubble can be described by the following line invariant:

$$ds_{\pm}^2 = g_{\mu\nu}^{\pm} dx^{\mu} dx^{\nu} = -f_{\pm}(r) dt_{\pm}^2 + f_{\pm}^{-1}(r) dr^2 + r^2 d\Omega_3^2, \quad (1)$$

where

$$f_{\pm}(r) = 1 + k_{\pm}^2 r^2 + \chi(r, k_{\pm}, q_1, \dots, q_m). \quad (2)$$

Here, r will denote the radial coordinate of the AdS_5 vacuum, i.e. the throat direction. The line-invariant $d\Omega_3^2 = \gamma_{ij} dx^i dx^j$ is the metric on S^3 , which corresponds to the three-dimensional solid angle for the usual spatial sections. The function $f_{\pm}(r)$ represents the usual AdS_5 geometry plus some possible extra features encoded in $\chi(r, k_{\pm}, q_1, \dots, q_m)$. These will be relevant in the following sections, but for now on, let us fix $\chi(r, k_{\pm}, q_1, \dots, q_m) = 0$.

CONTINUE EXPLANAINING PARAMETRISATION OF FOUR D AND STUFF.

2 DARK BUBBLES FROM STRING THEORY: AN EXPLICIT CONSTRUCTION

Here some general shity introduction about the general features of the model in 10D.

2.1 A rotating ten-dimensional black hole

Talk about whole construction that Oscar used and present all ingredients in the game. Two option: Describe the basics of the dual field theory here or create appendix about AdS/Cft ?

¹Other bubble dimensionalities have been explored in [IVANO STUFF]

2.2 Comparing junctions to EOM

Basically, compare as we did in the paper. Just to prove, that at some specific limit $EOM = JC$.

2.3 Higher curvature corrections to the rescue

Point to the fact that previous EOM has no CC. Discuss about how to obtain it and elaborate on all pieces in the game. End with the famous $1/N$ corrections that transform in CC. (First part of 5th paper)

2.4 Energy scales from Dark Bubble embedding: A new hope

Compare to observed CC and obtain N to fix all scales. Discuss and defend the size of extra dimensions and the stringy scales.

3 DECORATING THE COSMOS: GAUSS-CODAZZI EQUATION AT WORK

Argue somehow that we are going to look at things from a 5D perspective and will start to induce stuff in the 4D cosmos.

3.1 Matter

3.2 Radiation

3.3 Gravitational waves

3.4 The standard model of particle physics

3.4.1 Electromagnetism

3.4.2 Weak force: Neutrinos

4 HOLOGRAPHIC BUBBLES AND HANGING STRINGS

5 QUANTUM BUBBLES: HIGHER DIMENSIONS TO SOLVE BOUNDARY CHOICES

[1]

REFERENCES

- [1] U.H. Danielsson and T. Van Riet, *What if string theory has no de Sitter vacua?*, *Int. J. Mod. Phys. D* **27** (2018) 1830007 [1804.01120].