A tale of two non-SUSY DGKT vacua

Joan Quirant

Instituto de Física Teórica UAM-CSIC

CSIC Consejo Superior de Investigaciones Científicas

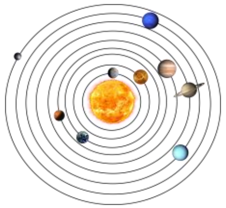
Based on: 2110.11370 with F.Marchesano and D.Prieto, 2204.00014 and 22xx.xx with F. Marchesano and M. Zatti

String phenomenology 2022

Motivation

- Current observations teach us that in our universe there appears to be

  - ➢ Scale separation
  - ➢ No SUSY (at energies tested so far)



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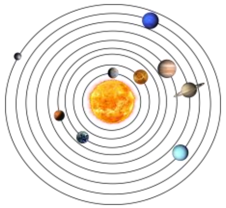

- Current computations teach us that in string theory

  - ➢ It is difficult to obtain fully controlled models with scale separation

  - ➢ Non-SUSY vacua seem to be always unstable

In this talk we will focus on these problems

Motivation

- Work with non-SUSY vacua of DGKT type

or

?

- Nice properties:
  - Parametrically scale separated (at large volume, weak coupling)
  - Perturbative stable
- Not that nice properties:
  - Complete solution to the 10d equations not known (smearing approximation)
  - Non-perturbative stability?

Contents

DGKT: a quick start guide

DeWolfe, Giryavets, Kachru, Taylor '05; Cámara, Font, Ibánez '05

- DGKT vacua: massive type IIA compactified on a CY orientifold with
    - NSNS H_3 and RR internal fluxes G_0, G_2, G_4, G_6 (democratic formulation $\boldsymbol{G} = \mathrm{vol}_4 \wedge \tilde{G} + G, \tilde{G} \sim *_6 G$).

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- They are very trendy these days
  - Obtained using directly the 4d effective theory and not solving the 10d EOM
  - Intersecting orientifold O6-planes: no complete uplift is known (only if the sources are smeared* Acharya, Benini, Valandro '07). Approximate uplift beyond the smearing approximation in Junghans '20, Marchesano, Palti, JQ, Tomassiello '20
  - Phenomenologically interesting : scale separation $R_{KK} \sim R_{AdS}^{7/9}$ at large volume and small string coupling.

  - In tension with the strong AdS distance conjecture (only for the SUSY vacua) Lust, Palti, Vafa '19

$*dF = H + \delta$ → Smearing approximation: $\delta = -H$

DGKT: a quick start guide

- Several branches of vacua (beyond the original SUSY one) derived in Marchesano, JQ, '19. Focus on:
  - Non-SUSY$_{G_4}$ related to the standard SUSY DGKT vacuum by $G_4 = -G_4^{\text{SUSY}}$
  - Non-SUSY$_{G_2}$ which has a harmonic component for G_2 different from 0, $G_2^{\text{harmonic}} \neq 0$
  - Perturbatively stable (checked in Marchesano, JQ '19) ✔
  - Non-perturbative stability for the Non-SUSY$_{G_4}$ studied in Aharony, Antebi, Berkooz '08; Narayan, Trivedi '10 using D4, D6 and D2 DW. At most marginal decays

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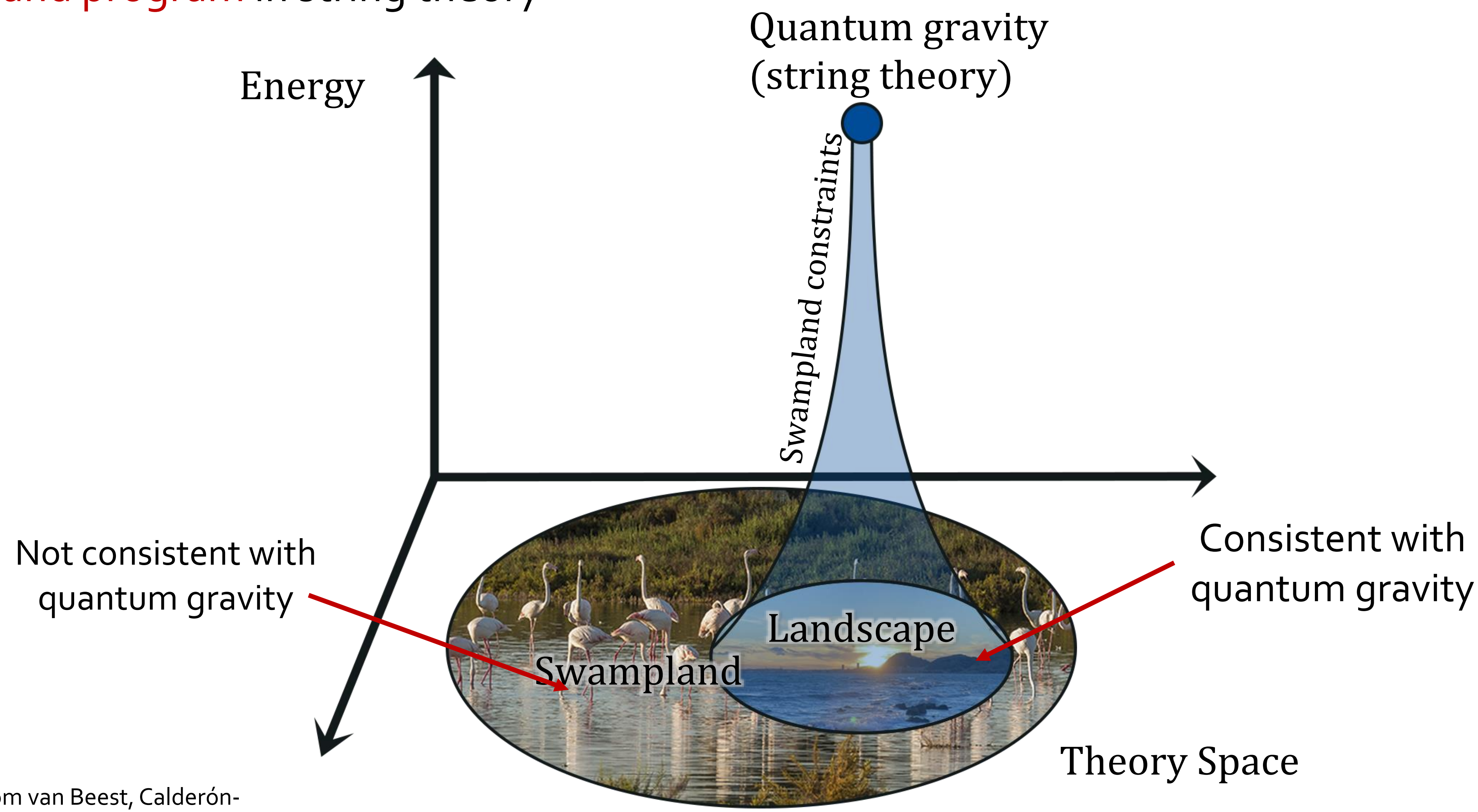
- What we can say about the validity/stability of the Non-SUSY$_{G_4}$ and the Non-SUSY$_{G_2}$ branches?

Two main tools: AdS/CFT correspondence and DW branes

A swampland in the room

- Swampland program in string theory



Adapted from van Beest, Calderón-Infante, Mirfendereski, Valenzuela '21

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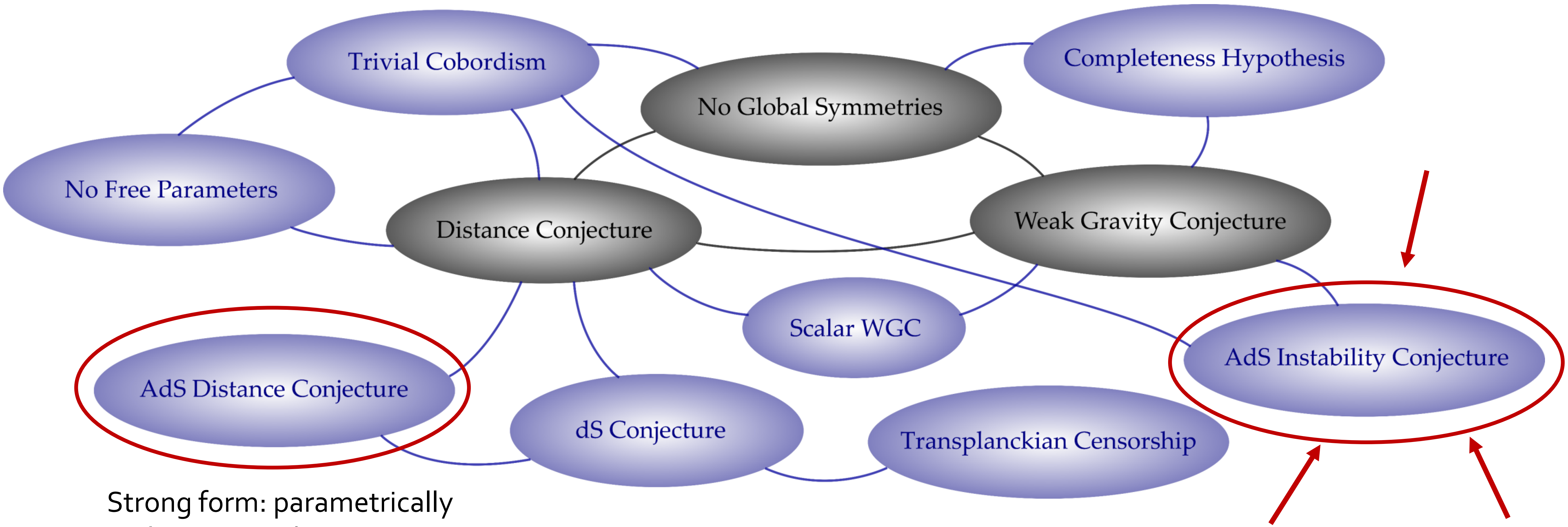

Strong form: parametrically scale separated SUSY vacua are in the swampland

AdS instability conjecture

Ooguiri, Vafa '16

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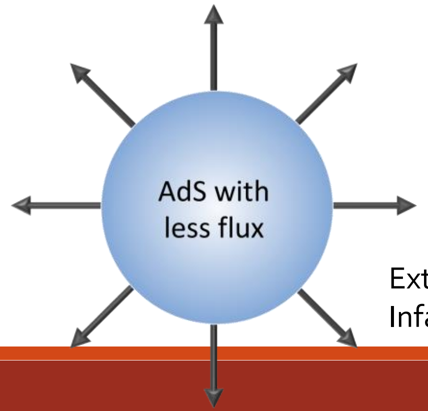
    Maldacena, Michelson, Strominger '99
  - Consequence II: this brane corresponds to an instability. Any non-SUSY AdS supported by fluxes is at best metastable.



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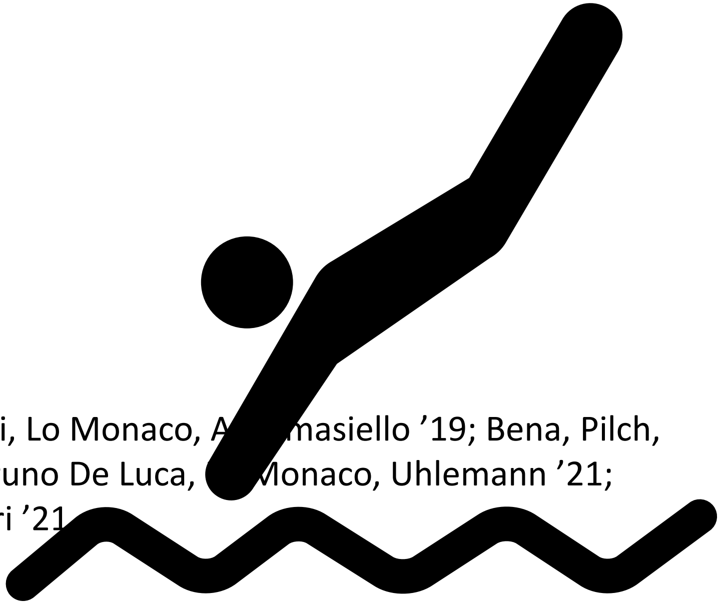

Computations

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  - For Non-SUSY$_{G_4}$: integer conformal dimensions JQ'22.

$$\Delta = 10, \quad \Delta_i = 1 \text{ or } 2, \quad \Delta_a = 6,$$
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For $i = 1, \dots, h^{2,1}$ and $a = 1, \dots, h_{-}^{1,1}$

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  - For Non-SUSY$_{G_2}$: non-integer conformal dimensions JQ'22

$$\Delta = \frac{1}{2}(3 + \sqrt{393}), \quad \Delta_i = \frac{1}{2}(3 + \sqrt{201}), \quad \Delta_a = 3,$$
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- According to this conjecture there should be a codimension one object (a DW from the 4d point of view) with $Q > T$
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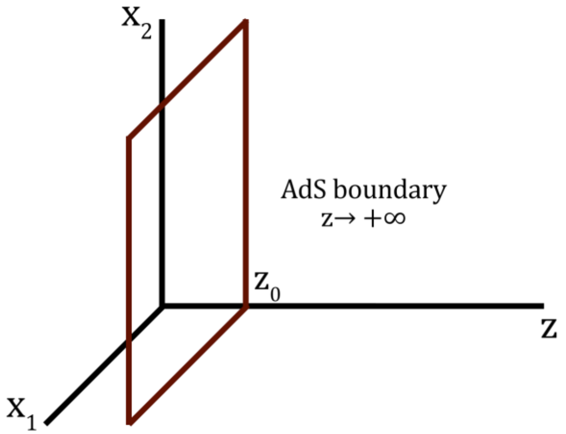
- Basic idea: consider the Poincaré for the AdS_4 metric $ds_4^2 = e^{\frac{2z}{R}}(-dt^2 + d\vec{x}^2) + dz^2$. Boundary in $z = +\infty$

Tension of a membrane spanning (t, x_1, x_2) and $z = z_0$ goes like $T \sim e^{3z_0/R}$ → inevitably driven away from the boundary



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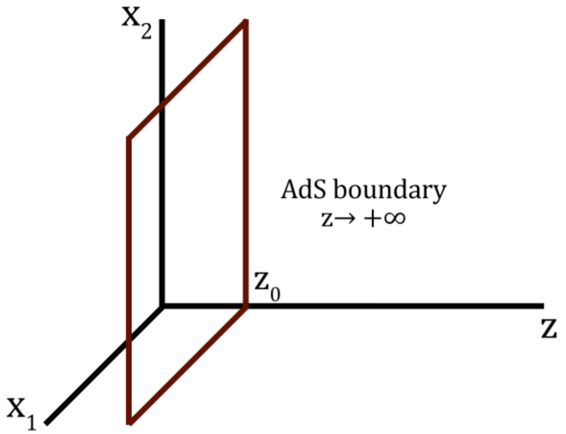

- This can be avoided considering the p-form potentials to which the membrane couples. Example $C_3 = Qe^{3z_0/R} dt \wedge dx^1 \wedge dx^2$ and $Q = T$ → equilibrium. If $Q > T$ → instability

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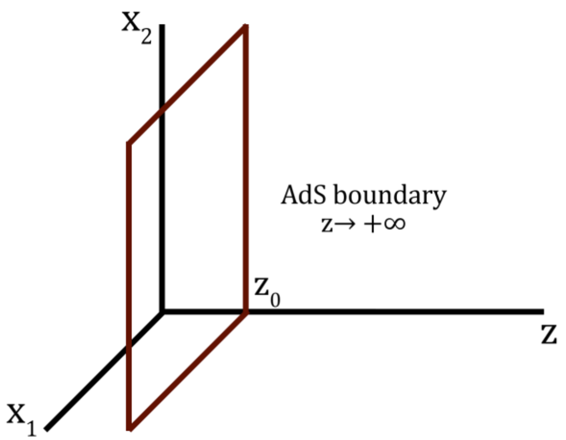

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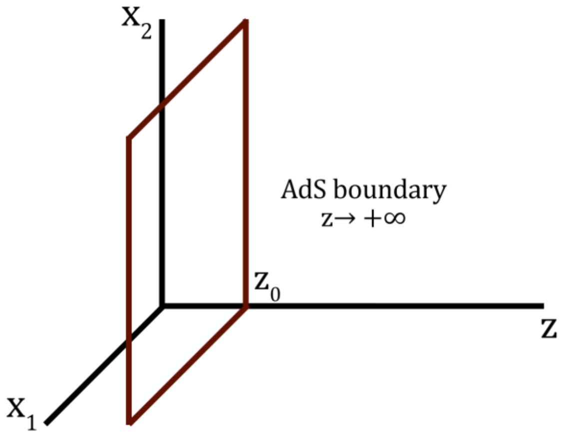

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Due to lack of time we will only focus on the Non-SUSY$_{G_4}$ branch

(remember $G_4 = -G_4^{\text{SUSY}}$)

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- Non-SUSY$_{G_4}$. The *internal* fluxes:

$$H = \frac{1}{2} F_0 g_s \mathrm{Re}\Omega_{CY}, \qquad G_0 = \frac{1}{l_s} m, \qquad G_2 = 0, \qquad G_4 = -\frac{3G_0}{10} J_{CY}^2, \qquad G_6 = 0$$

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$$C_9 = -\frac{5}{3e^{\phi}} e^{\frac{3z}{R}} dt \wedge dx^1 \wedge dx^2 \wedge \mathrm{dvol}_6 \qquad C_5 = -\frac{1}{e^{\phi}} e^{\frac{3z}{R}} dt \wedge dx^1 \wedge dx^2 \wedge \mathrm{dvol}_{2-\mathrm{cycle}}$$

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- And so the (naïve) charge of the DW branes will be obtained from the $S_{CS} = \int C \wedge e^{-\mathcal{F}}$, $\mathcal{F} = B + \frac{l_s}{2\pi} F$:

$$S_{\mathrm{CS}}^{D8} = \int C_9 + \frac{1}{2} \int C_5 \wedge \mathcal{F} \wedge \mathcal{F} \qquad S_{\mathrm{CS}}^{D6} = -\frac{1}{2} \int C_5 \wedge \mathcal{F} \qquad S_{\mathrm{CS}}^{D4} = -\frac{1}{2} \int C_5$$

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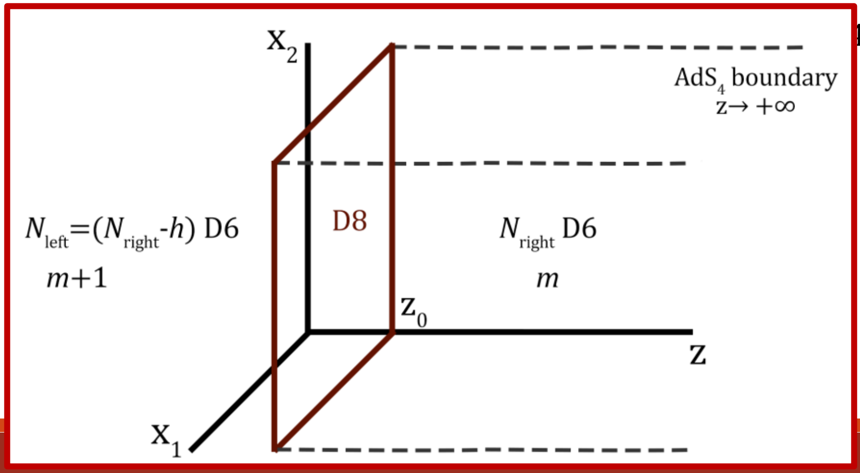
$$= -\frac{1}{2} \int C_5$$

Freed Witten anomaly for the $\mathcal{F}$ in the D8: $d\mathcal{F} = \mathrm{H} + \delta$ → need space-filling D6 to cancel the tadpole

$$Q_{DW}^{D8} = Q_{CS}^{D8} + Q_{\mathrm{DBI}}^{D6}$$



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  - Using Junghans '20, Marchesano, Palti, JQ, Tomassiello '20, going beyond the smearing approximation and considering curvature corrections $Q \gtrsim T$
  - First derived in Marchesano, Prieto, JQ ''21, Several explicit toroidal examples in Casas, Marchesano, Prieto '22.

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  - Already using the smearing approximation $Q > T$
  - Curvature and beyond smearing corrections supressed compared to the leading term
  - Though focused on the Non-SUSY$_{G_4}$ branch, the same seems to apply for the Non-SUSY$_{G_2}$ branch
  - AdS instability conjecture strongly satisfied → non-perturbative instability
  - More work still to be done. Please stay tunned! 

Conclusions

- Studied some properties (CFT dual, stability) of two non-SUSY DGKT vacua: Non-SUSY$_{G_4}$ ($G_4 = -G_4^{\text{SUSY}}$) and Non-SUSY$_{G_2}$ ($G_2^{\text{harmonic}} \neq 0$)

- Would-be CFT dual: for the Non-SUSY$_{G_4}$ integer conformal dimensions, for the Non-SUSY$_{G_2}$ non-integer conformal dimensions

- AdS instability conjecture: seems to be satisfied easily in both set-ups through DW D8 branes with internal $\mathcal{F} \sim J$. D6s ending on them to cancel the tadpoles. Need more work

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Thank you for your attention! 🙂