On type II AdS flux vacua in 3D

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Based on: 2311.08991; 2407.$\alpha\beta\gamma\delta\epsilon$ [arXiv/hep-th]

together with F. Farakos; Á. Arboleya, A. Guarino

Introduction

Introduction and Motivation

The majority of known SUSY AdS vacua of ST have

$$L_{\mathrm{AdS}} \sim L_{\mathrm{KK}} \ :$$

they do **not** exhibit **scale separation**.

Debated SUSY AdS_4 **scale-separated vacua**:

- The KKLT model [Kachru et alii, 2003];
- The DGKT construction [De Wolfe et alii, 2005].

Introduction and Motivation

In particular, **DGKT** classical scale-separated SUSY AdS_4 **vacua** [De Wolfe et alii, 2005]:

- **Setup and ingredients**

  (i) Massive type IIA SUGRA on CY_3 ($\mathbb{T}^6/\mathbb{Z}_3^2$ orientifold);

  (ii) Smeared O6 planes;

  (iii) Unbounded F_4 flux.

- A **criticism**. Smearing approximation.

Our purpose

- Search for **simpler** classical scale-separated AdS_3 flux **vacua** [Farakos et alii, 2021; 2311.08991];

- Find the most general flux choice allowing for scale-separation [*fundamenta ponentes* in 2407.$\alpha\beta\gamma\delta\epsilon$]?!

AdS_3 flux vacua from IIA orientifolds

Setup and Ingredients [Farakos et alii, 2021]

Massive type IIA SUGRA (in the Einstein frame) on a G2 space [Joyce, 1996]

$$\mathcal{X}_7 = \frac{\mathbb{T}^7}{\mathbb{Z}_2^\alpha \times \mathbb{Z}_2^\beta \times \mathbb{Z}_2^\gamma}\,;$$

3D spacetime-filling **O2 planes** and **smeared O6 planes**;

Unconstrained F_4 flux.

Then,

$$\frac{L_{\mathrm{KK}}^2}{L_{\mathrm{AdS}}^2} \ll 1 \text{ ?}$$

The effective construction [2311.08991]

We get a **three-dimensional**

$$\mathcal{N}=16 \xrightarrow{\mathrm{O2}} \mathcal{N}=8 \xrightarrow{\mathbb{Z}_2^\alpha} \mathcal{N}=4 \xrightarrow{\mathbb{Z}_2^\beta} \mathcal{N}=2 \xrightarrow{\mathbb{Z}_2^\gamma} \boxed{\mathcal{N}=1}$$

supergravity **Lagrangian** [Farakos et alii, 2021; Van Hemelryck, 2022]

$$e^{-1}\mathcal{L}=\tfrac{1}{2}R_3-\tfrac{1}{4}(\partial x)^2-\tfrac{1}{4}(\partial y)^2-\sum_{a=1}^{6}\frac{1+\delta_{ab}}{4\tilde{s}^a\tilde{s}^b}\partial\tilde{s}^a\partial\tilde{s}^b-V(x,y,\tilde{s}^a)$$

$$\text{with}\quad V(x,y,\tilde{s})=G^{IJ}\partial_I P\partial_J P-4P^2\,,$$

where the **superpotential** P depends on

$$F_0\,,\qquad H_3=\sum_{i=1}^{7}h_3^i\Phi_i\,,\qquad F_4=\sum_{i=1}^{7}f_{4,f}^i\Psi_i+\sum_{i=1}^{7}f_{4,q}^i\Psi_i\,,$$

(with e.g. $f_{4,f}^i=(2\pi)^3N^i$, $N^i\in\mathbb{Z}$).

Realizing scale separation [2311.08991]

For the **flux choice**,

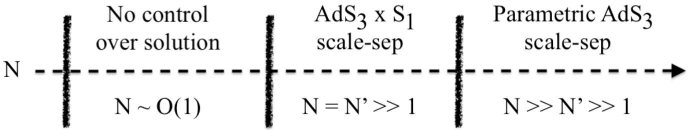
$$h_3 = h(1,1,1,1,1,1,1)\,;$$

$$f_{4,f} = f(1,1,1,-3,0,0,0)\,, \qquad f_{4,q} = q(0,0,0,0,1,1,-2)\,,$$

while proceeeding **numerically**, we get

$$\frac{L^2_{\mathrm{KK,a}}}{L^2_{\mathrm{AdS}}} \to 0\,, \quad \frac{L^2_{\mathrm{KK},7/5}}{L^2_{\mathrm{AdS}}} \gtrsim 1\,, \quad g_s \ll 1\,, \quad g_s^{\frac{1}{4}}\, r_i \gg 1\,,$$

and, more exhaustively,



. . . Appetizing a generalization . . .

A crash course on half-maximal 3D SUGRA [Deger et alii, 2019]

$$e^{-1}\mathcal{L} = -\frac{1}{4}\,R - \frac{1}{32}\,D_\mu M\,D^\mu M^{-1} - \,V + \ldots$$

with

$$\mathcal{V}(\phi) \in \mathcal{M}_{\rm scal} = \frac{\rm SO(8,8)}{\rm SO(8)\times SO(8)} \qquad \text{and} \qquad M = \mathcal{V}\,\mathcal{V}^T\,.$$

We define

$$D_\mu M = \partial_\mu M - 2\,g\,A_\mu \cdot \Theta\;T \cdot M\;,$$

where the **embedding tensor** is

$$\Theta_{MN|PQ} \quad \equiv \quad \theta_{[ABCD]} \quad \oplus \quad \theta_{(AB)} \quad \oplus \quad \theta \qquad (\text{with } M = 1,\ldots,8,\overline{1},\ldots,\overline{8}),$$

satisfying **quadratic constraints** (QC)

$$\Theta_{MN|PQ}\;\left(T^{PQ}\right)_R{}^S\Theta_{ST|UV} + \cdots = 0\;.$$

Type IIA with an O2 plane [2407.$\alpha\beta\gamma\delta\epsilon$]

	AdS_3			$\mathbb{T}^7$						
With an O2 plane	x^0	x^1	x^2	y^1	y^2	y^3	y^4	y^5	y^6	y^7
	$\times$	$\times$	$\times$							

acting as $\sigma_{\mathrm{O2}} \, : \quad y^m \longrightarrow -y^m \qquad (\text{for } m = 1, \dots, 7)$,

Fields	${e_n}^p$	C_1	Φ	C_3	B_2	B_6	C_5
$\mathcal{O}_{\mathbb{Z}_2} = \Omega_P \cdot \sigma_{\mathrm{O2}}$	$+$	$+$	$+$	$-$	$-$	$+$	$+$

Fluxes	${\omega_{mn}}^p$	F_2	H_1	F_4	H_3	H_7	F_6
$\mathcal{O}_{\mathbb{Z}_2} = \Omega_P \cdot \sigma_{\mathrm{O2}}$	$-$	$-$	$-$	$+$	$+$	$-$	$-$

Then, **group theoretically**:

$$H_3 \equiv \theta^{mnpq} \,, \qquad F_4 \equiv \theta^{mnp8} \,, \qquad F_0 \equiv \theta^{88} \,.$$

Type IIA with an O2 plane [2407.$\alpha\beta\gamma\delta\epsilon$]

Specializing to a $(\mathbb{Z}_2 \times \mathbb{Z}_2) \times \mathbb{Z}_2$ invariant sector, i.e.

$$\mathcal{M}_{\text{scal}} = \left[\frac{\text{SL}(2)}{\text{SO}(2)}\right]^8 \subset \frac{\text{SO}(8,8)}{\text{SO}(8)\times\text{SO}(8)} \quad \oplus \quad \text{other eight scalars} = 0\,,$$

we get the **half-maximal scalar potential**

$$g^{-2}\, V_{\mathcal{N}=8} = \frac{\sigma^4}{32}\left[\sum_{m=1}^{7}\left(\frac{h_m}{\sqrt{s^m_{(4)}}} - f_m\sqrt{s^m_{(4)}}\right)^2\right] + \frac{\sigma^2}{32}\, F_0^2 \prod_{m=1}^{7} s_m^2\,,$$

together with the **half-maximal QC**

$$F_0\; H_3 = 0 \qquad \Longleftrightarrow \qquad \text{absence of O6/D6}\,.$$

Its vacuum structure: for $F_0 = 0$, $\mathbf{Mkw_3}$ at $s^m_{(4)} = \frac{h_m}{f_m}$.

Adding O6 planes [2407.$\alpha\beta\gamma\delta\epsilon$]

Adding three independent types (1_α, 2_β, 3_γ) of **O6 planes**,

$$\mathcal{N}=16 \underset{\text{O2}}{\longrightarrow} \mathcal{N}=8 \underset{\text{O6}_\alpha}{\longrightarrow} \mathcal{N}=4 \underset{\text{O6}_\beta}{\longrightarrow} \mathcal{N}=2 \underset{\text{O6}_\gamma}{\longrightarrow} \boxed{\mathcal{N}=1}$$

and

$$-F_0\, H_3 = J_{\text{O6/D6}} \neq 0 \ ,$$

so that

$$g^{-2}\, V_{\text{O6}} = \frac{\sigma^3}{16}\, F_0 \sum_{m=1}^{7} \left(h_m\, s^m_{(3)} \sqrt{s^m_{(4)}} \right) \ .$$

Moreover,

$$V_{\mathcal{N}=1} = V_{\mathcal{N}=8} + V_{\text{O6}} \quad \equiv \quad G^{IJ}\partial_I P \partial_J P - 4P^2 \quad \text{in [2311.08991].}$$

Which **fluxes** generally allow for (partial/full) **scale separation**?

Conclusions

Concluding Remarks

- We constructed new SUSY AdS_3 vacua with(out) scale-separation while maintaining large volume and weak coupling, respecting flux quantization and stabilizing the closed-string moduli;
- We described a correspondence between stringy orientifold reductions/3D half-maximal supergravity, which seems a florid ground to explore interesting phenomenological questions.

Future directions

Exempli gratia:

- Charting the landscape of (Mkw_3 and AdS_3) vacua of 3D half-maximal supergravity [In progress, Arboleya, Guarino and MM];
- Thanks to the embedding tensor formalism, the most general flux choice giving scale-separation in the setup of [2311.08991] [In progress, Arboleya, Guarino and MM];
- O6-plane backreaction at higher orders [Building on Junghans, 2020. In progress, Emelin];
- Detailed investigation of 3-dimensional de Sitter uplifts [In progress, Farakos et alii];

Thank you for your interest and attention!