A landscape of AdS Flux Vacua

Joan Quirant Pellín

Work in progress,
in collaboration with Fernando Marchesano

Instituto de Física Teórica UAM-CSIC

CSIC Consejo Superior de Investigaciones Científicas

UAM Universidad Autónoma de Madrid

(*traditional*) Motivation

- Phenomenology: type IIA on Calabi-Yau orientifolds and D6-branes

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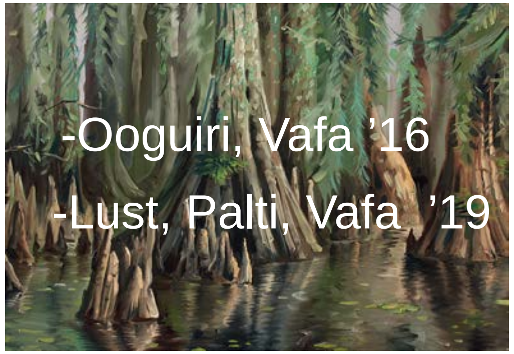
- Moduli stabilization via flux compactification 

(*swamplandistic*) Motivation

- Several conjectures involving AdS vacua



- Limited class of examples in type IIA + CY orientifold + fluxes. Most of them with particular geometry (like T^6)

-DeWolfe, Girayavets, Kachru, Taylor ’05
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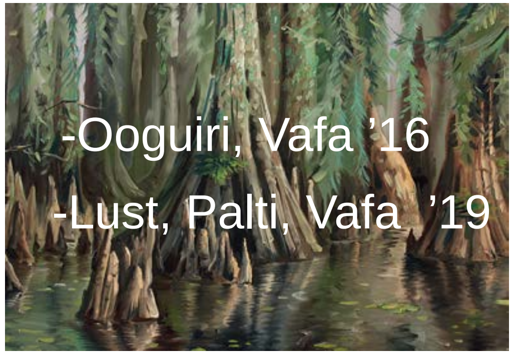

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Need for a systematic and more general search of vacua.

Framework

- Type IIA at large volume on a CY orientifold: $\mathrm{CY}_3/\Omega_p(-)^{F_L}\mathcal{R}$
- Fluxes turned on: $\begin{cases} \text{RR: } F_0,\ F_2,\ F_4,\ F_6 \\ \text{NSNS: } H_3 \end{cases}$

$$F_0 \leftrightarrow m \quad F_2 \leftrightarrow m^a \quad F_4 \leftrightarrow e_a$$
$$F_6 \leftrightarrow e_0 \qquad H_3 \leftrightarrow h_\mu$$

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↓

- Scalar potential in the 4d effective action:

$$V_F = \frac{e^K}{\kappa_4^2}\left[\left(\partial_A W + K_A W\right) K^{A\bar{B}} \left(\partial_{\bar{B}}\bar{W} + K_{\bar{B}}\bar{W}\right) - 3|W|^2\right]$$

Framework

- One can rewrite the potential as:

$$V_F = \frac{1}{\kappa_4^2} \rho_A Z^{AB} \rho_B$$

Herráez, Ibáñez, Marchesano, Zoccarato, ’18

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- ρ_B depend on the flux quanta and the axions

- ρ_B invariant under axionic shift symmetries

$$\rho_0 = e_0 + e_a b^a + \frac{1}{2}\mathcal{K}_{abc} m^a b^b b^c + \frac{m}{6}\mathcal{K}_{abc} b^a b^b b^c + h_\mu \xi^\mu,$$

$$\rho_a = e_a + \mathcal{K}_{abc} m^b b^c + \frac{m}{2}\mathcal{K}_{abc} b^b b^c,$$

$$\tilde{\rho}^a = m^a + m b^a,$$

$$\tilde{\rho} = m,$$

$$\hat{\rho}_\mu = h_\mu.$$

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- ρ_B depend on the flux quanta and the axions
- ρ_B invariant under axionic shift symmetries
- Z^{AB} depends only on the saxions:

$$Z^{AB} = e^K \begin{pmatrix} 4 & & & & & \\ & K^{a\bar{b}} & & & & \\ & & \frac{4}{9}\mathcal{K}^2 K_{a\bar{b}} & & & \\ & & & \frac{1}{9}\mathcal{K}^2 & \frac{2}{3}\mathcal{K}s & \frac{2}{3}\mathcal{K}u^j \\ & & & \frac{2}{3}\mathcal{K}s & K^{s\bar{s}} & K^{s\bar{u}_j} \\ & & & \frac{2}{3}\mathcal{K}u^i & K^{u_i\bar{s}} & K^{u_i\bar{u}_j} \end{pmatrix}$$

Results

$$\rho_0 = e_0 + e_a b^a + \frac{1}{2}\mathcal{K}_{abc} m^a b^b b^c + \frac{m}{6}\mathcal{K}_{abc} b^a b^b b^c + h_\mu \xi^\mu,$$
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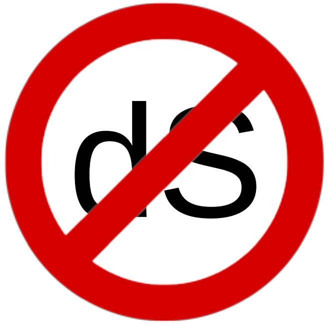
1. Easily:

$$\left(u^\mu \partial_{u^\mu} V + \frac{1}{3} t^a \partial_{t^a} V\right) = -3V - \frac{8e^K}{27}\mathcal{K}^2 \tilde{\rho}^a \tilde{\rho}^b K_{ab} - 8e^K \rho_0^2 - \frac{4e^K}{3} K^{ab} \rho_a \rho_b$$



Consistent with: Hertzberg, Kachru, Taylor, Tegmark ’08

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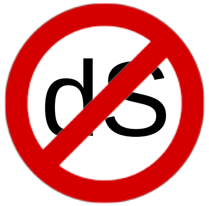
1. Easily: 

2. All the vacua seem to satisfy:

Solvable only knowing (part of) the explicit form of the metric.

$$\rho_0 = 0$$

Only a linear combination of complex axions is stabilised

$$\hat{\rho}_\mu = \tilde{\rho} A \mathcal{K} \partial_{u^\mu} K + \tilde{\rho}\hat{\epsilon}^{p}_{\mu}$$

$$\tilde{\rho}^a = \text{“}\pm\text{”} B \tilde{\rho} t^a$$

$$\rho_a = \text{“}\pm\text{”} C/3 \tilde{\rho} \partial_{t^a} K$$

Depends on the form of the metric

Results

A lot of vacua

All of them consistent with Cámara, Font, Ibáñez ’05

Branch	A	B	C	Λ	SUSY?
A1-S1	$\frac{1}{15}$	0	$\frac{3}{10}$	$-\frac{4e^K}{75}\mathcal{K}^2\tilde{\rho}^2$	Yes
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A1-S2	$\frac{1}{30}$	0	$\pm\frac{\sqrt{6}}{10}$	$-\frac{8e^K}{225}\mathcal{K}^2\tilde{\rho}^2$	No
A1-S2	0	0	0	0	No
A2-S1	$\frac{1}{12}$	$\pm\frac{1}{2}$	$-\frac{1}{4}$	$-\frac{e^K}{18}\mathcal{K}^2\tilde{\rho}^2$	No
A2-S2	$\frac{1}{28}$	$\pm\frac{1}{14}$	$-\frac{1}{4}$	$-\frac{11e^K}{294}\mathcal{K}^2\tilde{\rho}^2$	No

Already found in Escobar, Marchesano, Staessens ’18

(perturbative) stability?

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Branch	Tachyons?	How many?	Physical eigenvalue	
A1-S1, Susy	Yes	$\boxed{N}$ = number of (complexified) complex moduli	$m^2_{tach} = \frac{8}{9} m^2_{BF}$	✔
A1-S1, Non-Susy	Yes	$\boxed{N} + \boxed{1}$, N = number of (complexified) complex moduli	$m^2_{tach} = \frac{8}{9} m^2_{BF}$	✔
A2-S1	No	-	-	✔

- N tachyons: come from the complex saxionic directions
- +1 tachyon: comes from the complex+Kähler axionic direction

Validity of the solutions

$$F_4 \leftrightarrow e_a \sim e$$

Unconstrained by the tadpole equations

- Scale analysis (*Grosso modo*):

-Large volume, weakly coupled? For large e:

F_4 density

$$\mathcal{V}^0_{\rm CY} \sim e^{3/2} \qquad e^D \sim e^{-3/2} \qquad e^{\phi} \sim e^{-3/4} \qquad \bar{F}_4 \sim e^{-3/2}$$

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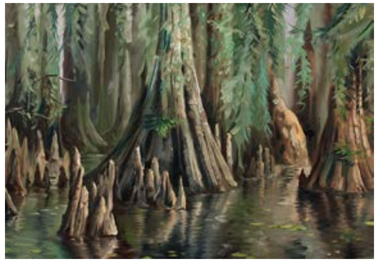

$$M_{kk} \sim e^{-7/4} M_{Pl} \qquad \Lambda \sim -M_{Pl}^2 e^{-9/2}$$

$$M_{kk} \sim |\Lambda|^{7/18}$$

Consistent with the weak ADC of Lüst, Palti, Vafa ’19

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Warning: we do not have studied their stability/ validity

All the previous solutions and branches can be generalised including the mobile D6-branes!

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- A lot of different AdS Vacua. The ones we have analysed are perturbatively stable. 🎉

- Including mobile D6-branes: we can extend our solutions easily. 🆒

Outlook

- Extend the formalism to different compactifications? Ex. Coset manifolds
- Non-perturbative stability?
- 10d description?

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Thank You!