Supersymmetry Breaking Warped Throats and the Weak Gravity Conjecture

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GB, E. García-Valdecasas, A. Uranga [arXiv:1810.07673]

cf. talk by Eduardo

String Phenomenology, Geneva, 27th June 2019

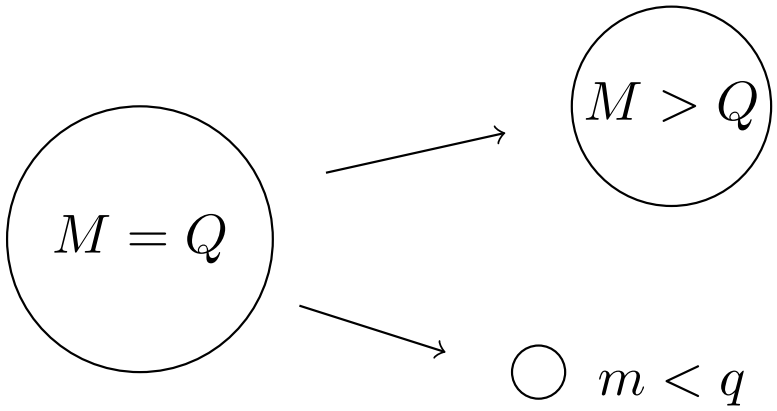
Gravity as the weakest force

[Arkani-Hamed MotI Nicolis Vafa 2007]

WGC: given an abelian gauge field, there exists a charged particle with mass

$$M \leq Q \qquad \text{(in units where } M_{Pl} = 1\text{)}$$

Motivated by the need for extremal black holes to decay



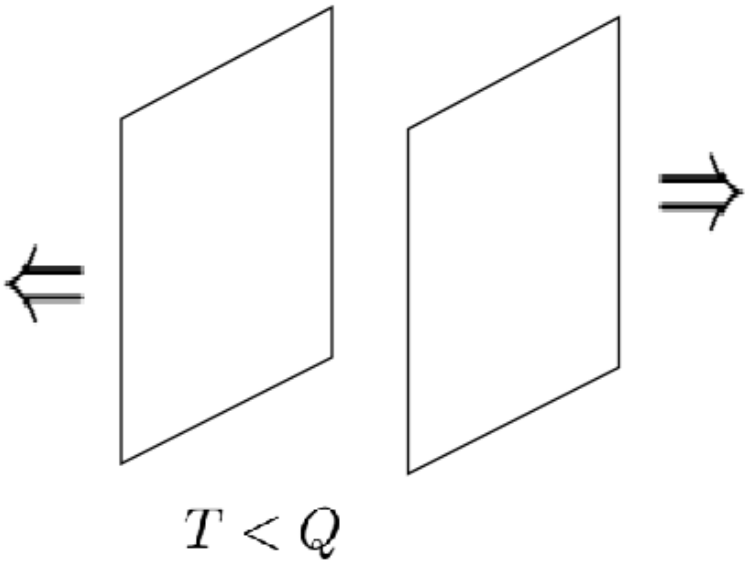
Also, given a $(p+1)$-form gauge potential, there exists a p-brane with tension

$$T \leq Q$$

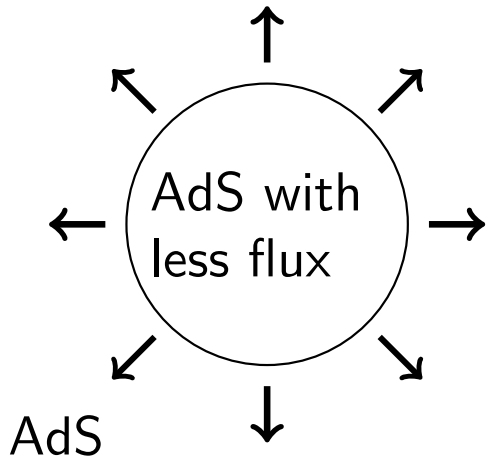
Non susy AdS and the swampland

refined WGC: $T = Q \Leftrightarrow$ BPS states in a susy theory

[Ooguri Vafa 2017]



- AdS is tipically obtained in holography from the near-horizon limit of a configuration of branes
- A possible decay channel for non susy AdS supported by flux is through brane nucleation



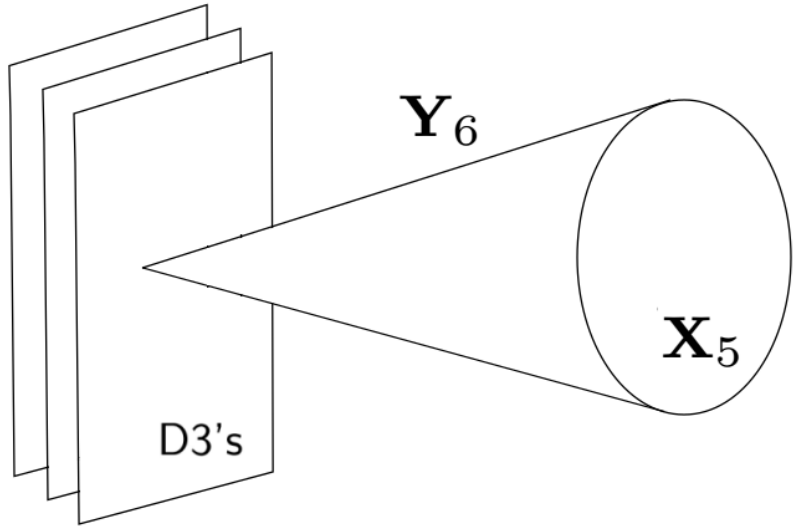
AdS-WGC: all non susy AdS vacua must be *unstable*

Still true for "locally" AdS backgrounds?

Warped throats

- N regular + M fractional D3's probing a CY singularity

$$ds^2_{\mathbf{Y}_6} = dr^2 + r^2 ds^2_{\mathbf{X}_5}$$



- For $M = 0$, the gauge theory is *conformal*.

  $AdS_5 \times \mathbf{X}_5$ gravity dual with constant RR 5-form flux N over X_5

  $\Rightarrow$ usual AdS-WGC

- For $M \neq 0$, the gauge theory is no more conformal and undergoes a non trivial RG flow.

  The gravity dual is a *local* AdS solution

Warped throats

- RR 3-form flux $\int_{\Sigma_3} F_3 = M$ constant
- NSNS 3-form flux $\int_{\Sigma_2} B_2 \sim g_s M \ln r \qquad H_3 = dB_2$
- RR 5-form flux $\int_{\mathbf{X}_5} F_5 = N(r) \sim g_s M^2 \ln r$

$$ds^2 = Z(r)^{-1/2}\, \eta_{\mu\nu}\, dx^\mu\, dx^\nu \,+\, Z(r)^{1/2}\, [\, dr^2 \,+\, r^2 ds^2_{\mathbf{X}_5}\,]$$

with $Z(r) = \dfrac{L^4}{r^4} \ln\left(\dfrac{r}{r_s}\right) \qquad L^2 \sim g_s M \qquad r_s$ naked singularity

The local AdS-WGC

In a consistent theory of quantum gravity, there are no stable non-supersymmetric solutions with asymptotics given by local AdS backgrounds

We do **not** rule out:

- metastable throats (no infinite volume factor multiplying the decay probability, in contrast with the usual AdS-WGC)

  $\Rightarrow$ no direct contradiction with dS uplift

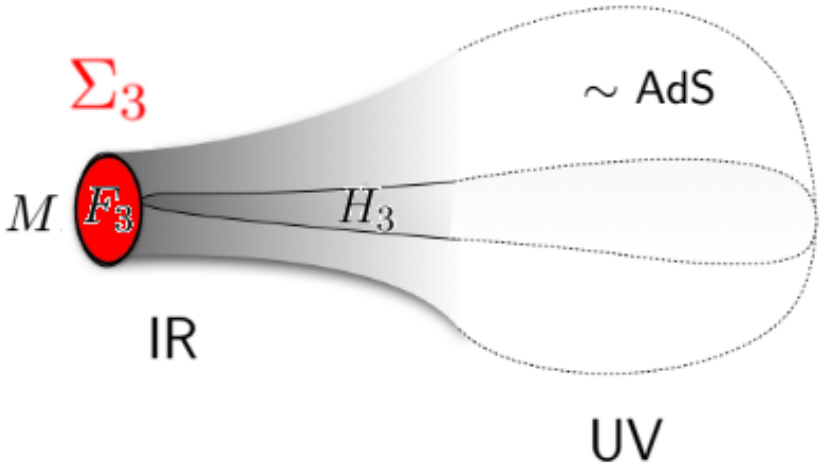
- warped throats with asymptotics modified by ingredients in the bulk

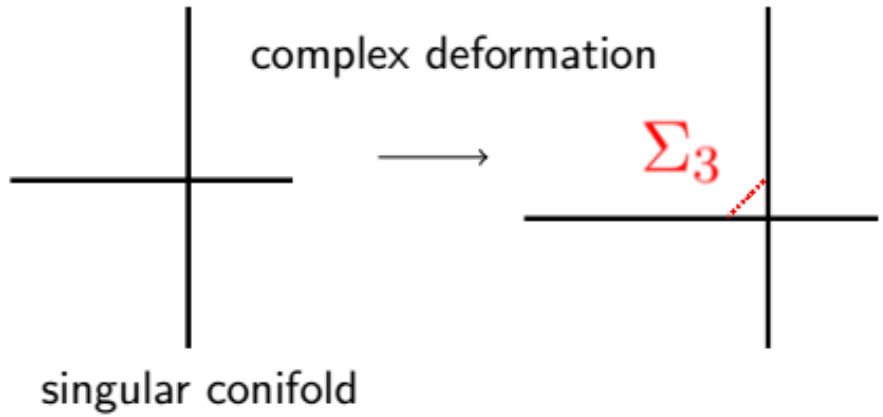
Evidence from deformation branes

Different classes of fractional branes, in particular:

- deformation branes, associated to complex deformations of the singular manifold

[Klebanov Strassler 2000] + ...





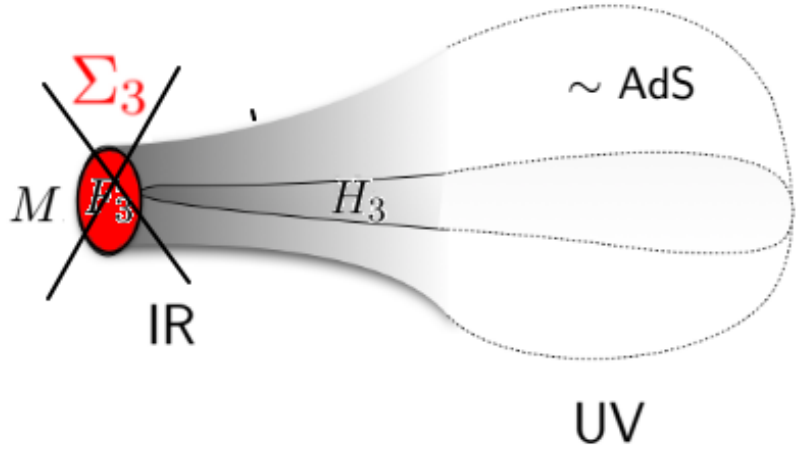
The naked singularity can be smoothed out by giving Σ_3 a finite size, while preserving supersymmetry

$\Rightarrow$ The local AdS-WGC is satisfied

Evidence from DSB branes

- DSB branes, not associated to complex deformations

Σ_3 cannot be given a finite size, while preserving supersymmetry



If one could smooth out the IR region to an alternative susy breaking *stable* configuration, this would contradict the local AdS-WGC...

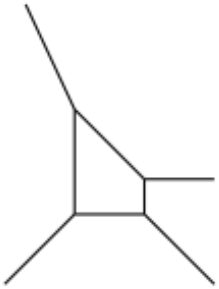
But we argue that this is not possible

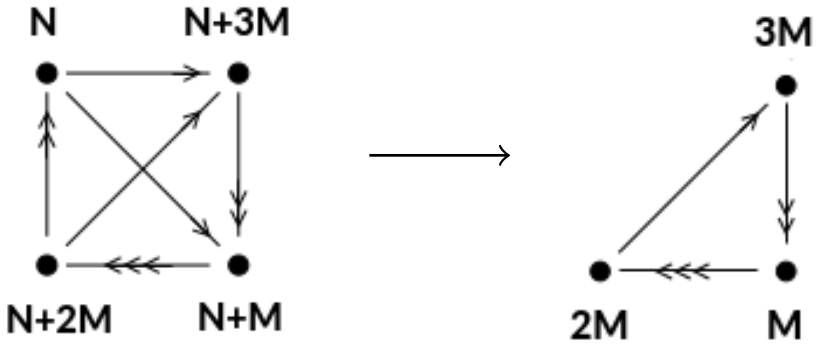
cf. Eduardo's talk

The dP_1 runaway

simplest example of a duality cascade triggered by DSB branes

[Berenstein Herzog Ouyang Pinansky 2005] [Bertolini Bigazzi Crotone 2005] [Franco Hanany Saad Uranga 2005]





- no susy minimum
- runaway behaviour

The gravity dual is not known, but the field theory analysis suggests that smoothing of the singularity would break susy and involve some instability

Introducing orientifold planes

- Large number N of regular D3's, possibly with extra M deformation branes, on top of an anti-O3 plane
- The corresponding AdS or local AdS backgrounds feel the absence of susy at 1-loop
- If *fully* stable, they would contradict both the AdS-WGC and the local AdS-WGC

Dynamics of D3's and anti-O3's

[Witten 1998] [Uranga 2000]

Four possible kinds of anti-O3 planes:

D-brane description	$(\theta_{NS}, \theta_{RR})$	Tension	RR charge
anti-($\mathrm{O3}^-$)	$(0,0)$	$-1/2$	$+1/2$
anti-($\mathrm{O3}^-$) + 1 $\overline{\mathrm{D3}}$	$(0,1/2)$	$+1/2$	$-1/2$
anti- $\mathrm{O3}^+$	$(1/2,0)$	$+1/2$	$-1/2$
anti- $\widetilde{\mathrm{O3}}^+$	$(1/2,1/2)$	$+1/2$	$-1/2$

in D3 units

Under type IIB $SL(2,\mathbf{Z})$, the anti-($\mathrm{O3}^-$) is a singlet and the other three transform into each other

Now introduce N D3's

D-brane description	$(\theta_{NS}, \theta_{RR})$	Tension	RR charge
anti-(O3$^-$)	$(0,0)$	$-1/2$	$+1/2$

- The gravitational and gauge interactions are both repulsive and the D3's are repelled

D-brane description	$(\theta_{NS}, \theta_{RR})$	Tension	RR charge
anti-(O3$^-$) + 1 $\overline{\text{D3}}$	$(0,1/2)$	$+1/2$	$-1/2$

- The D3's are attracted, but when reaching stringy distances a single D3 can annihilate with the stuck $\overline{\text{D3}}$, which is replaced by another D3. In the final configuration, the gauge repulsion overcomes the gravitational attraction and the D3's are repelled

D-brane description	$(\theta_{NS}, \theta_{RR})$	Tension	RR charge
anti- $\mathrm{O3}^+$	$(1/2, 0)$	$+1/2$	$-1/2$

- The gravitational and gauge interactions are both attractive, so there is no obvious instability at weak coupling. However, strong-weak type IIB duality relates the anti-($\mathrm{O3}^+$) at strong coupling to the anti-($\mathrm{O3}^-$) + 1 $\overline{\mathrm{D3}}$ at weak coupling, thus impling that the system is unstable at strong coupling

D-brane description	$(\theta_{NS}, \theta_{RR})$	Tension	RR charge
anti- $\widetilde{\mathrm{O3}}^+$	$(1/2, 1/2)$	$+1/2$	$-1/2$

- As in the previous case, an instability is expected because the system is related to the anti-($\mathrm{O3}^-$) + 1 $\overline{\mathrm{D3}}$ via an $SL(2, \mathbf{Z})$ transformation

Conclusions

- We propose a new swampland conjecture generalizing the AdS-WGC to locally AdS backgrounds and forbidding stable non susy warped throats with local AdS asymptotics
- Its application allows to reinterpret known results about warped throats from fractional branes
- We also derived new results on the (in)stability properties of large classes of non susy warped throats, providing further evidence for both the AdS-WGC and the local AdS-WGC

Thank you!