Testing the weak gravity conjecture using type I strings with broken supersymmetry

Quentin Bonnefoy

Centre de Physique Théorique - École Polytechnique

based on arXiv:1811.11199 and work in progress,
in collaboration with E. Dudas and S. Lüst

SUSY 2019
May 23rd, 2019

The swampland and the weak gravity conjecture

Consistent effective field theories: anomalies, unitarity, etc

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When coupled to quantum gravity: a **landscape** and a **swampland** Vafa '05

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Swampland conjectures characterize the landscape , ex:

- no exact global symmetries — see Banks, Seiberg '10
- completeness of the charge lattice — Polchinski '03
- distance conjecture — Ooguri, Vafa '06
- weak gravity conjecture — Arkani-Hamed, Motl, Nicolis, Vafa '06
- no stable non-SUSY AdS — Ooguri, Vafa '16
- de Sitter conjecture — Obied, Ooguri, Spodyneiko, Vafa '18

Weak gravity conjecture: Arkani-Hamed, Motl, Nicolis, Vafa ’06

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One of the best motivated conjectures: arguments from BHs, holography, string theory...

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For every p-form field, there must exist a charged (extended) object such that $e^2 Q^2 \geq 8\pi G \left(\frac{\alpha^2}{2} + \frac{p(d-p-2)}{d-2} \right) T^2$

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In what follows:

a test of the WGC for the R-R 2-form in type I string theory with broken supersymmetry

The string theory setup

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Unoriented worldsheets, ex: one-loop closed amplitude in 10-dimensional spacetime

$$\frac{1}{2}\mathcal{T} = \frac{1}{2}\# \int_{\mathcal{F}} \frac{d^2\tau}{\tau_2^6} \left| \frac{V_8 - S_8}{\eta^8} \right|^2 (\tau)$$

$$\left[V_8 = \frac{\theta_3^4 - \theta_4^4}{2\eta^4} \;,\; S_8 = \frac{\theta_2^4 + \theta_1^4}{2\eta^4} \right]$$

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Always understood as a **spontaneous breaking**

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$$+ (|O_8|^2 + |C_8|^2)\Lambda_{m,2n+1} - (O_8\bar{C}_8 + C_8\bar{O}_8)\Lambda_{m+1/2,2n+1} \} \frac{1}{|\eta^8|^2}$$

~~SUSY~~ generates **exponential quintessence-like runaway potentials**:

$$V = -\left(\frac{\mathcal{T}}{2} + \mathcal{K} + \mathcal{A} + \mathcal{M}\right) \sim \Lambda^4 e^{-c\Phi}$$

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~~SUSY~~ enables tests of the mutual compatibility of swampland conjectures

D1-D1 interactions and WGC

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Closed string exchange $\Longleftrightarrow$ open-string cylinder calculation (with Dirichlet-Dirichlet boundary conditions):

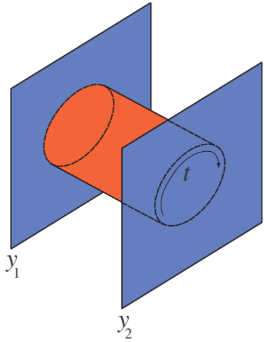

figure from JHEP 0305 (2003) 055

We focus on D1-D1 systems:

$$\mathcal{A}_{11} = \frac{1}{\pi\sqrt{\alpha'}} \int_0^\infty \frac{d\tau_2}{\tau_2^{3/2}} e^{-\frac{\tau_2 r^2}{4\pi\alpha'}} \left[P_m - P_{m+1/2}\right] \frac{\theta_2^4}{2\eta^{12}} \left(\frac{i\tau_2}{2}\right)$$

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Does this violate the WGC?

No.

No.

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$$V_{11} \sim \frac{1}{M_P^2}\left[\frac{\frac{4}{3}Q^2 - M^2 - \frac{1}{3}M^2 e^{-m_\phi r}}{r} - \frac{Q^2}{6}\frac{e^{-r\sqrt{\frac{R^2}{\alpha'^2}-\frac{2}{\alpha'}}}}{r}\right]$$

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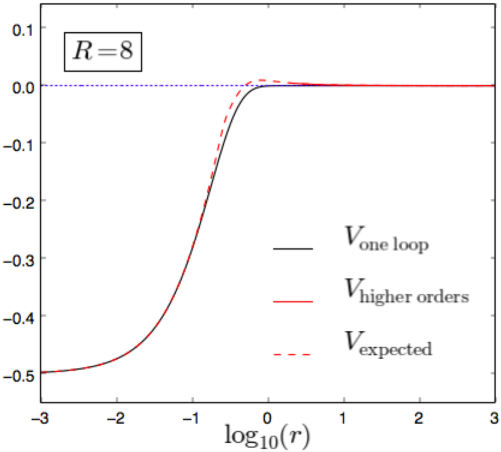

Outlook

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Future directions: other SUSY and non-SUSY tests (ex: more gauge fields)

Thank you!