Vacua Stability in String Theory

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STRING THEORY

What is String Theory ?

- Leader Theory for a Unified theory of quantum Gravity

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Point Particles States

Quantum excitation modes of Strings

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Many new features. Ex.:

- Unification of Gravity with SM
- Supersymmetric spectra for model construction
- Extra space-time dimensions (10 in supersymmetric theory)

STRING THEORY

Theoretical Evidences

- Recover Einstein eq.s
- SM Gauge group embedded in Higher symmetry group
- Maths (mirror symmetry, algebraic and non-commutative geometry, modular forms…)
- …
- Black Hole entropy

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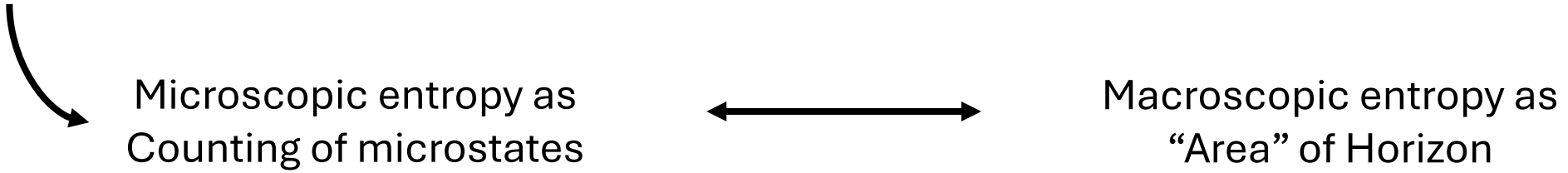

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Challenges

- Not testable
- Not yet a Supersymmetry breaking mechanism
- Swampland Conjectures = Very stringent Constraints

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- In the low energy limit recover SM and Einstein eq.s
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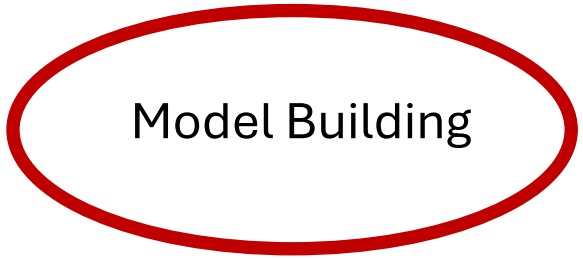

COMPACTIFICATION

Kaluka-Klein theory:

$$\mathcal{M}^{10} = \mathcal{M}^{4} \otimes \mathcal{M}^{6}$$

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- Non-geometric manifold
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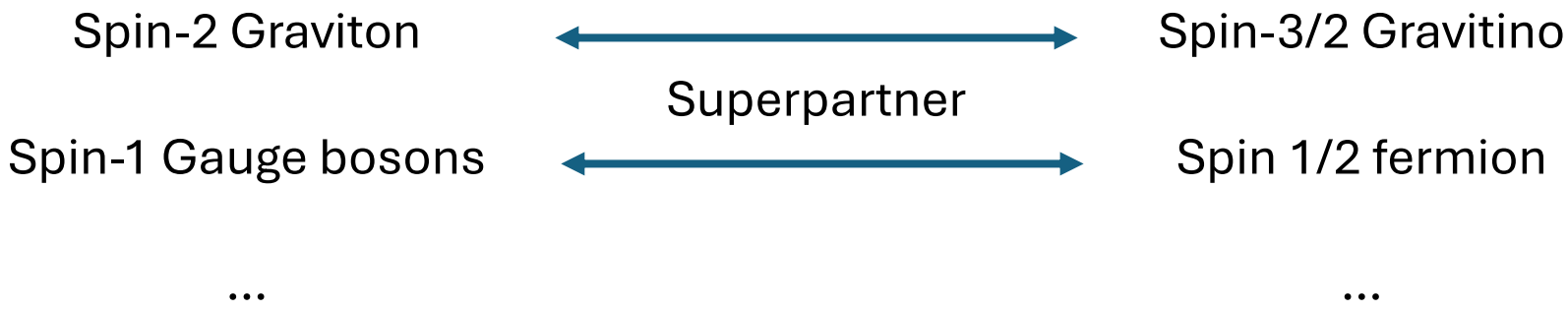
10^{500} Vacua

SUPERSYMMETRY

Spontaneous Scherk-Schwarz SUSY breaking:



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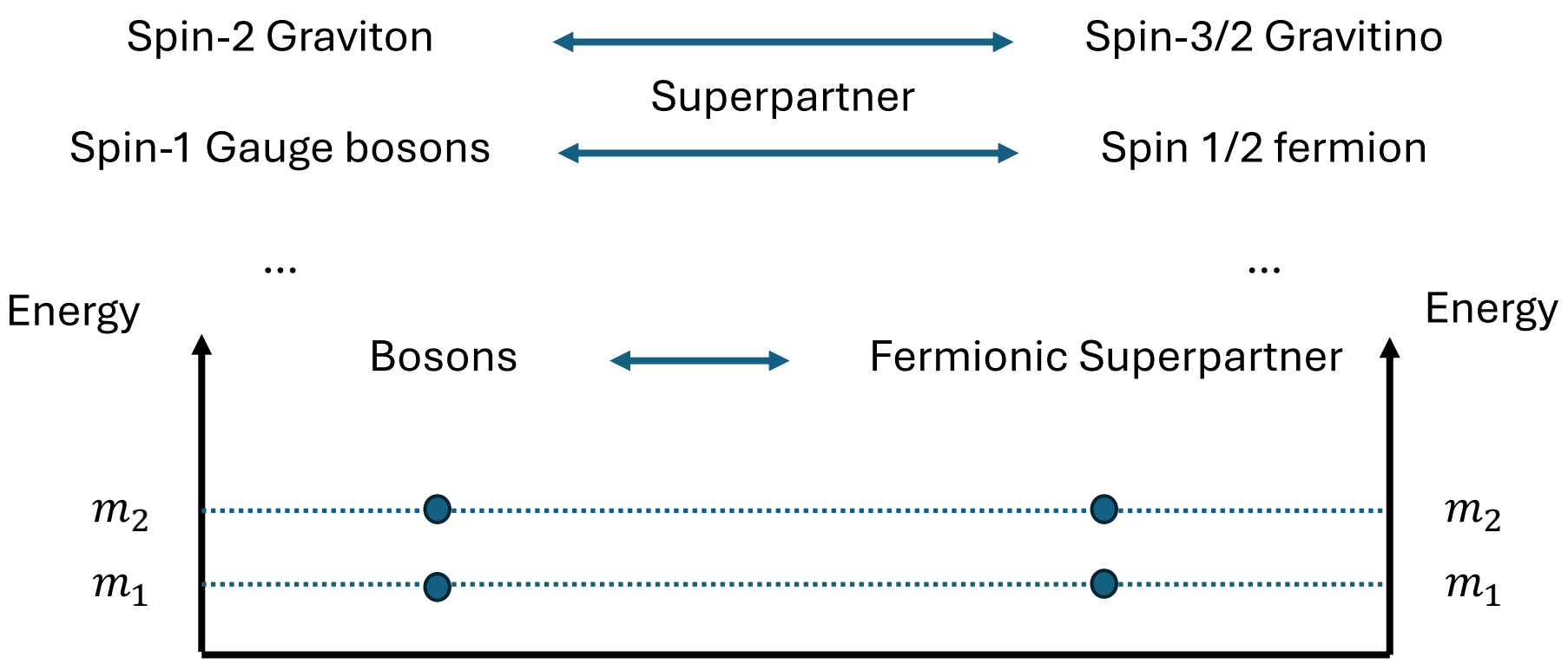

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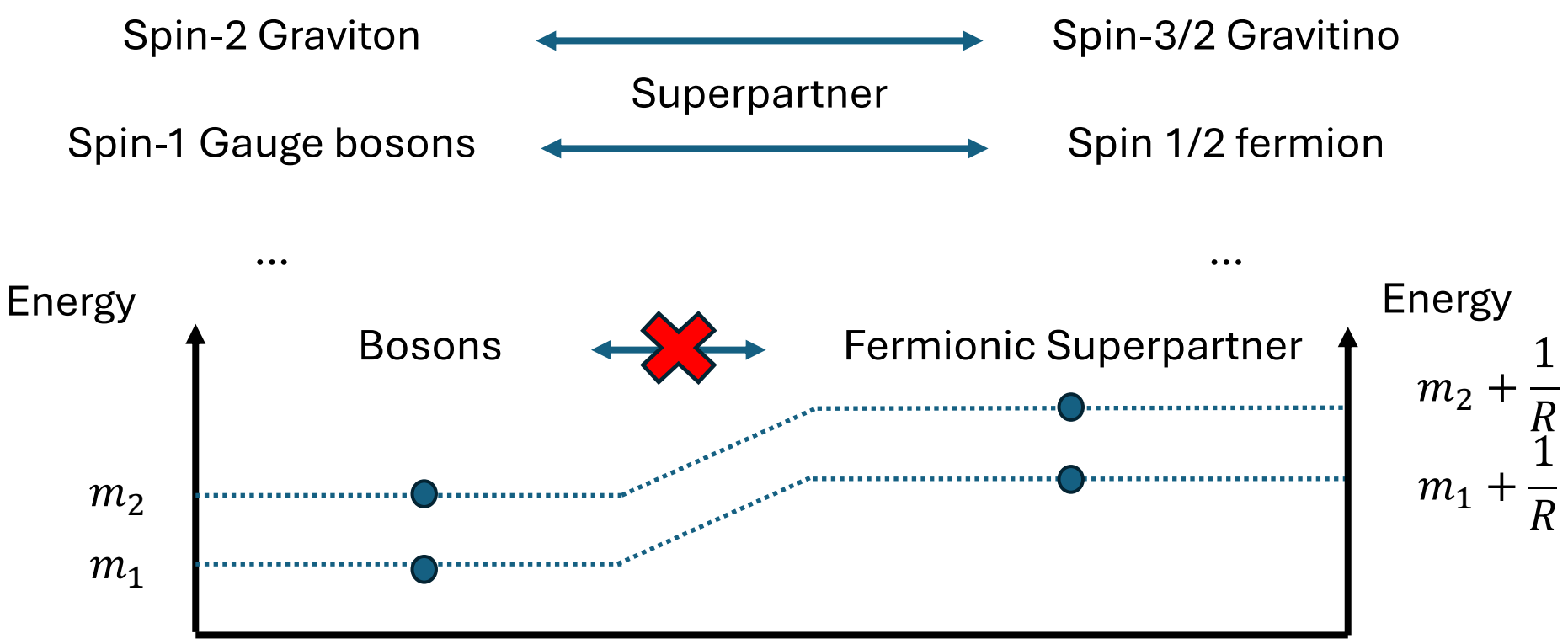
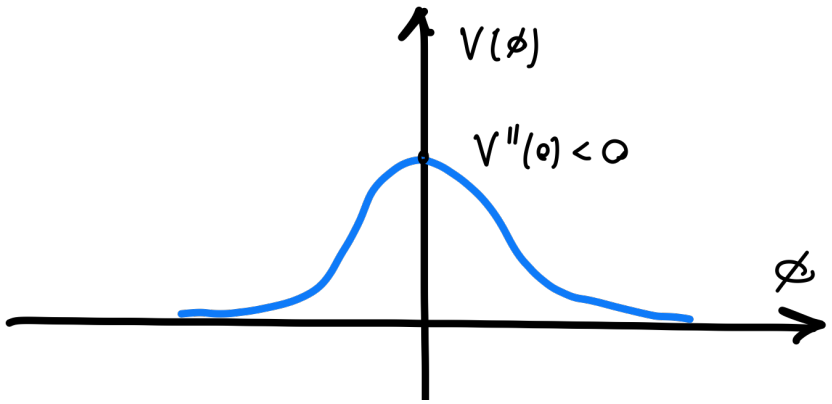


TACHYONS

Tachyons $m^2 < 0$

- Supersymmetric theory → Tachyon-free
- Broken Supersymmetry → Tachyons might appear



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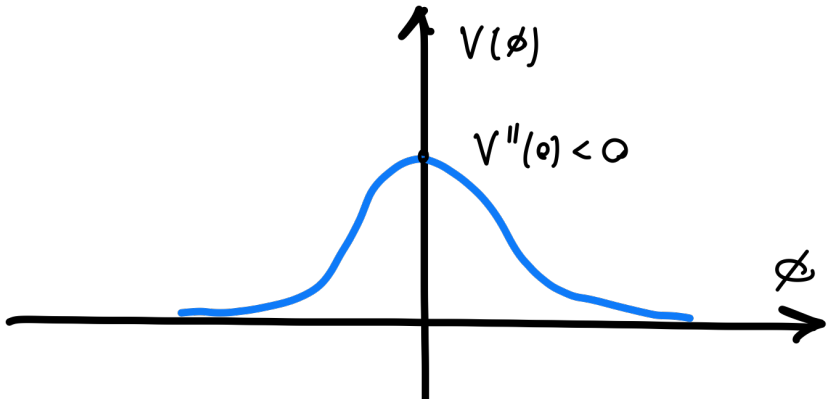
$\mathbb{Z}_2 \times \mathbb{Z}_2$ non-SUSY Heterotic / Type II closed string orbifold

Does our theory develop tachyons ?



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- How we break SUSY
- How we construct the Partition function

  (Suitable choice of Projectors, Fluxes)
- Particular choice of Geometry

Tachyon-free
At tree-level

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What happens at 1-loop ?

$$m^2 = m^2_{tree-level} + m^2_{one-loop}$$

Vertex Operator algebra

Tachyon-free
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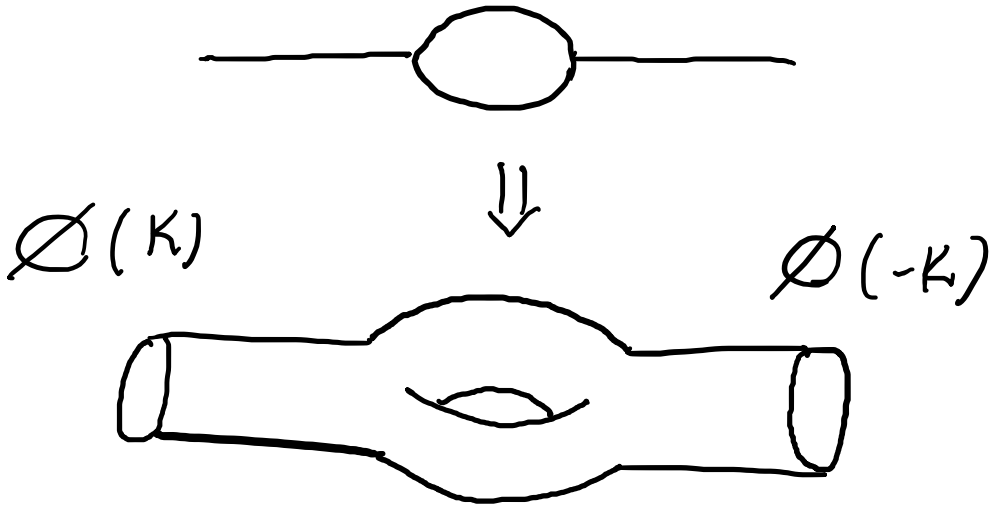

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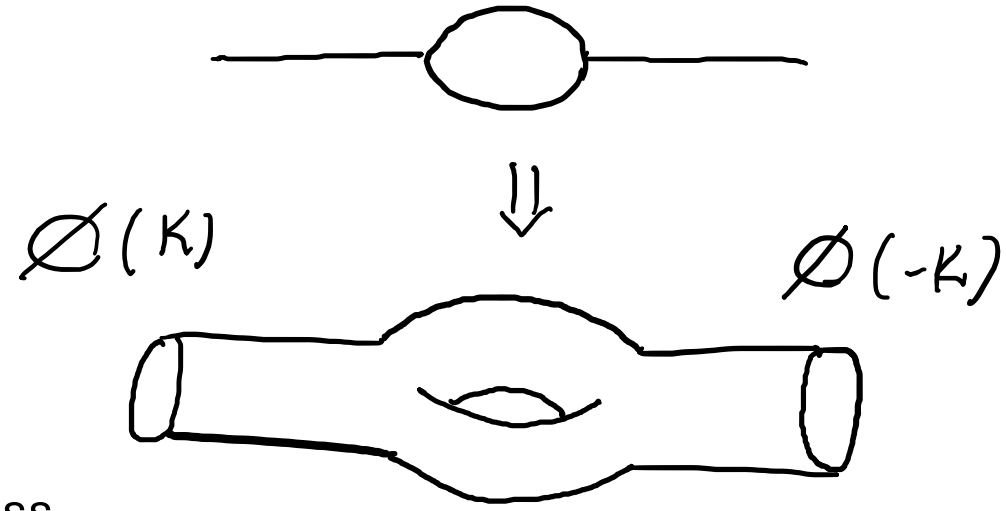

Still work in progress ...

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AdS Vacua only $\Lambda < 0$ (Conjectured ?)

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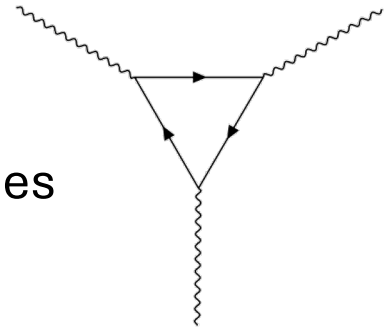
Green-Schwarz mechanism:

Usually there are U(1) anomalies in ST, in principle problematic, but not true anomalies



Anomaly cancelled by the 'anomalous' variation of some other field(s)

$$\mathcal{L} \xrightarrow{U(1)} A_\mu \to A_\mu + \partial_\mu \Lambda \quad \to \quad \delta\mathcal{L} \sim \xi\, \Lambda F^2$$

$$\mathcal{L} + \phi\, F^2 \xrightarrow{U(1)} \phi \to \phi - \xi\, \Lambda \quad \to \quad \delta\mathcal{L} = 0$$

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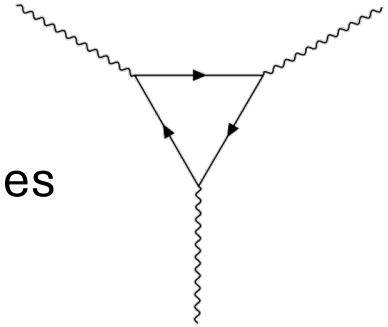

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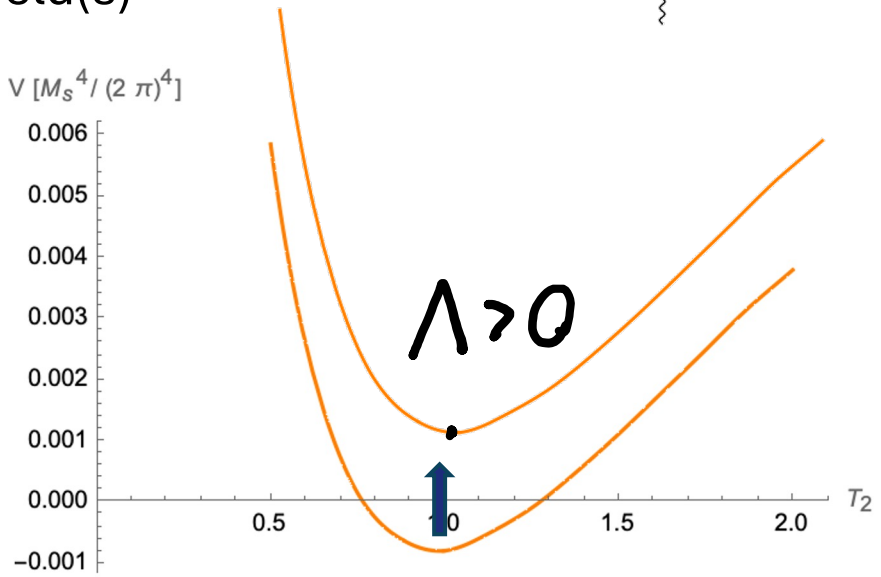
Generation of Constant Fayet-Iliopoulos D-term FI $[M^4]$

$$\Lambda + FI > 0$$



CONCLUSIONS

String theory leader candidate as QG theory

Our analysis

- Tachyon stability at tree-level and one-loop
- Vacuum uplift from AdS to dS Space

→ Analysis of stability in other dual String theories and Non-Geometric configurations

→ Exponentially suppressed Λ

→ Phenomenologically attractive models

THANK YOU