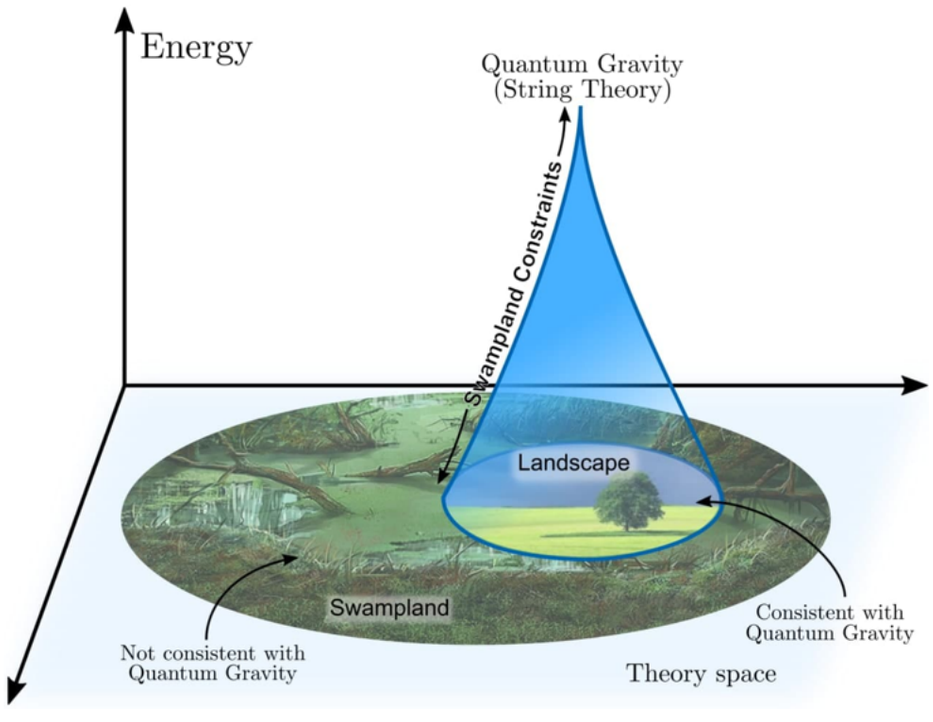
Connections between Swampland and Bootstrap



Irene Valenzuela

CERN

IFT UAM-CSIC

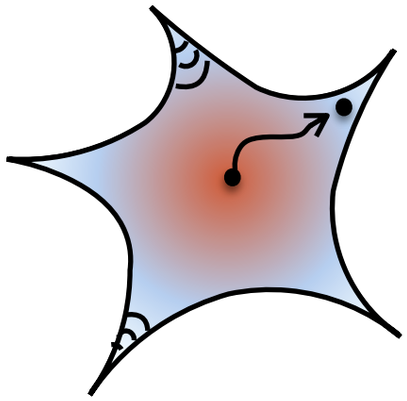
Strings 2025 conference
Abu Dhabi

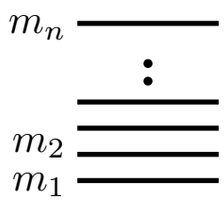
European Research Council
Established by the European Commission

I) CFT Distance Conjecture

Distance Conjecture

[Ooguri-Vafa'06]





$\exists$ infinite tower of states becoming light at infinite distance in field space

$$m \sim m_0 e^{-\alpha \Delta\phi} \quad \text{as} \quad \Delta\phi \to \infty \,;\, \alpha \geq \frac{1}{\sqrt{D-2}}$$

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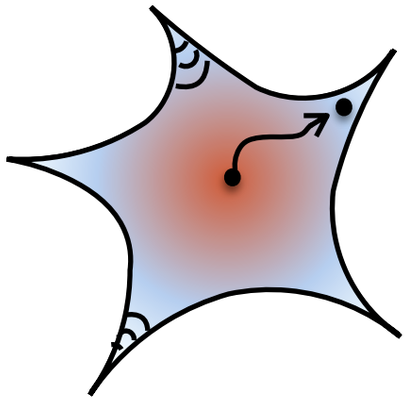

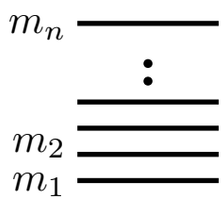

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Infinite distance
measured by Zamolodchikov metric

$$|x-y|^{2d}\langle O_i(x) O_j(y)\rangle = g_{ij}(t^i)$$

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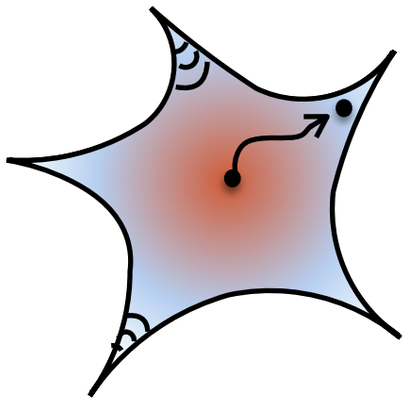

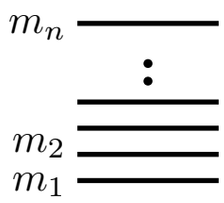

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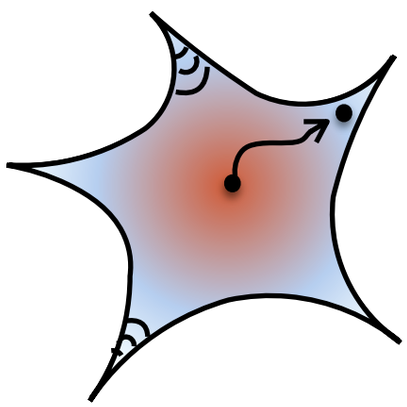

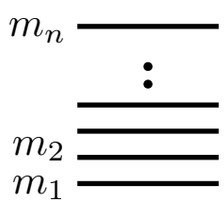

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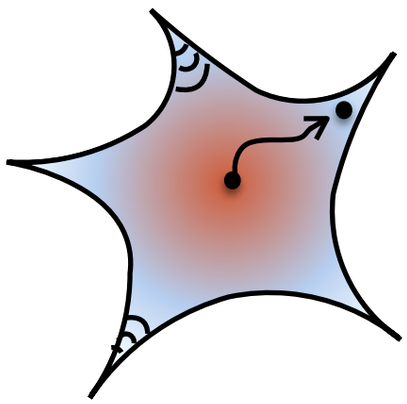

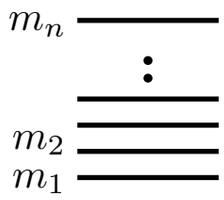

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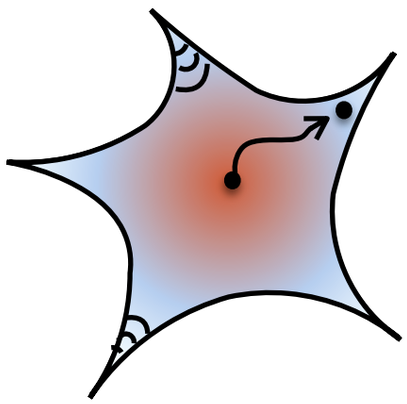

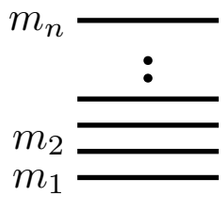

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Microscopic nature?

- In 2d: scalar modes (KK towers in the target space)
- In 4d: HS fields map to (non-)critical strings in (non-)holographic theories [Calderon-Infante,IV'24]

2) Species scale

Species scale / quantum gravity cut-off → scale at which local QFT (coupled to Einstein gravity) breaks down

$$\Lambda \leq \frac{M_p}{N^{1/(d-2)}}$$

[Arkani-Hamed et al'05]
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- String scale
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Bounds on the light spectra? [Hillman et al'24]

e.g. bound on number of massless fields?

Soft theorems to bound $\frac{\vec{\nabla}_\phi \Lambda}{\Lambda}$? [Cheung,Helset,Parra-Martinez'21]

3) Breaking of global symmetries

What is the minimal breaking allowed for a global symmetry in quantum gravity?

[Fichet,Saraswat '19] [Daus et al '20] [Harlow,Shaghoulian '20] [Chen,Lin '20] [Hsin et al '20] [Yonekura '20] [Cordova et al '22] [Bah,Chen,Maldacena'22]

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$$|\mathcal{A}|^2 \gtrsim e^{-S_{\rm BH}} \sim e^{R_{\rm BH}^{d-2}} \sim e^{-\left(\frac{M_p}{\Lambda}\right)^{d-2}}$$

$S_{\rm BH}$: entropy of smallest semiclassical black hole

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Most examples exhibit a stronger breaking, but some saturate the bound

e.g. NS axion in Type IIB on $\mathbb{T}^6$

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No violation of this bound so far. Can we put it on a firmer footing?