Super-Planckian Moduli Displacements and Quantum Gravity

(DK, Eran Palti, arxiv:1610.00010)

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Outline

- Several conjectures constrain possible effective field theories (EFTs) descending from quantum gravity (QG)
- These constraints can be directly relevant for experimentally accessible physics probing the Planck scale, e.g. large field inflation and have been successfully used to constrain such models
- We test a possible connection between two of these conjectures by studying super-Planckian *spatial* scalar field variations

Moduli in Quantum Gravity

- Aim: Derive low energy EFTs as vacua of quantum gravity
- Typically continuous families of vacua
  (different values of couplings)
- Parametrised by massless scalar moduli
  (e.g. geometric deformations of higher dimensional spacetime)
- Span manifold $\Rightarrow$ moduli space

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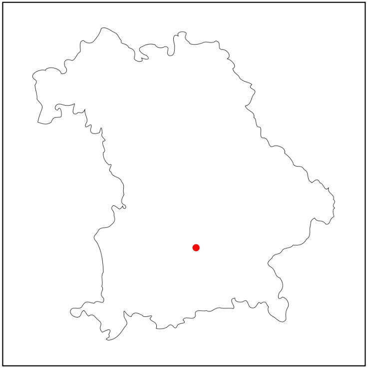
The Swampland Program

- Not every consistent looking effective field theory can arise from a quantum gravity theory in the UV [Vafa ('05)]



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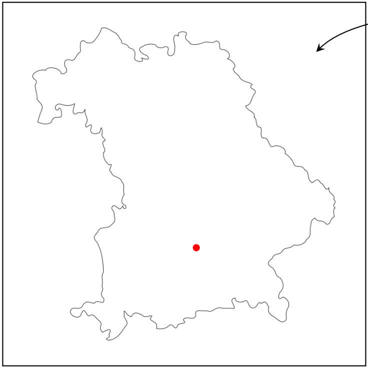

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Landscape

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The Standard Model

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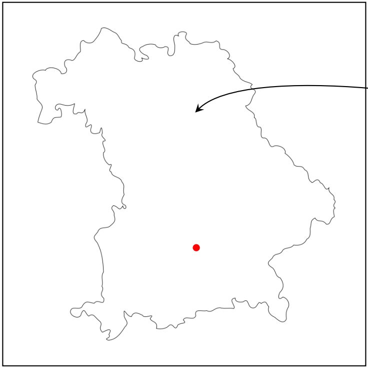

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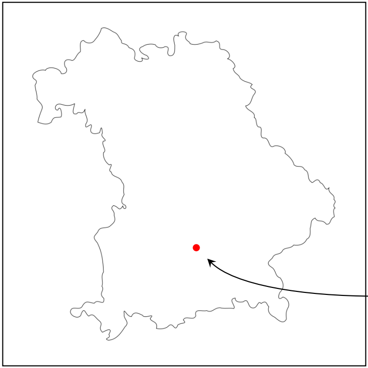

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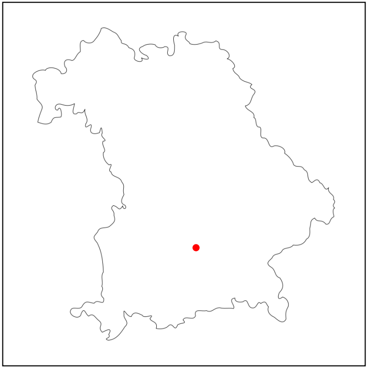

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1. Learn from String Theory
2. Theoretical consistency conditions

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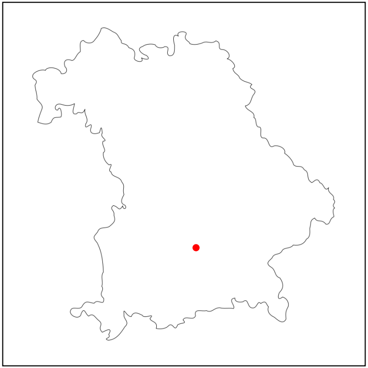

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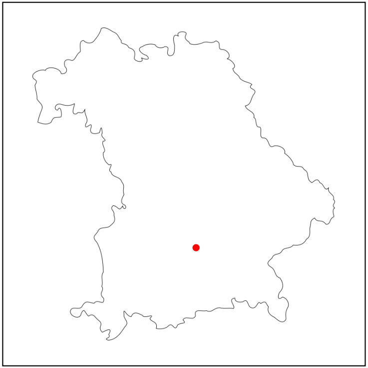

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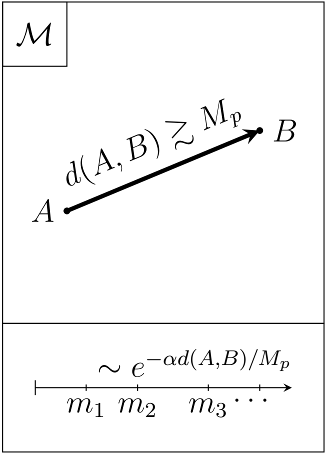

- "Swampland Conjecture" [Vafa ('06)]:

1. For any A $\exists$ B at arbitary large distance
2. If we displace from A to B there appears an infinite tower of states, exponentially light in the distance

- We show: for $\Delta\phi \gtrsim M_p$

$$m_{\mathrm{SC}}(\phi_0 + \Delta\phi) \lesssim m_{\mathrm{SC}}(\phi_0) e^{-\alpha\Delta\phi/M_p}$$

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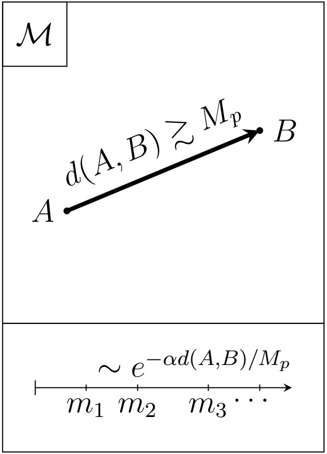

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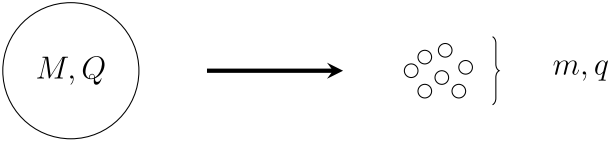

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- Black holes should evaporate to avoid pathological remnants
- Weak Gravity Conjecture [Arkani-Hamed et al. ('06)]: Should $\exists$ charged state with $m \lesssim gqM_p$
- Magnetic version: Should $\exists$ cutoff $\Lambda \lesssim gM_p$
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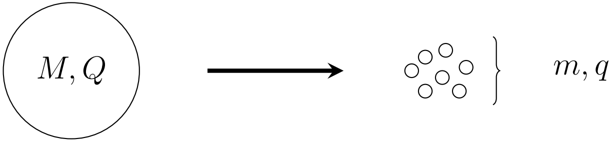

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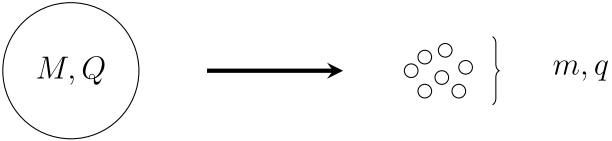

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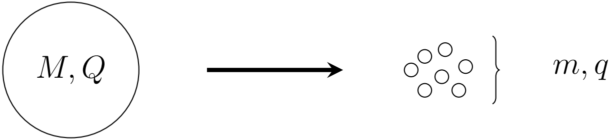

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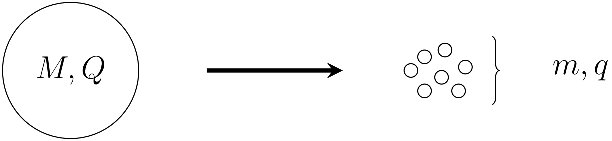

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The Gauge Coupling as a Modulus

- In WGC reasoning m, g were constant
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A Local Weak Gravity Conjecture

- Study spatially varying moduli and impose local WGC

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\begin{aligned}
m_{\mathsf{WGC}}(r) &\leq g(r) M_p \\
\rho(r)^{\frac{1}{2}} &\leq g(r) M_p^2
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Spatially Varying Moduli — Setup

- Study Einstein-Maxwell-Dilaton system

$$S = \frac{M_p^2}{2} \int d^4x \sqrt{-g} \left[R - 2(\partial\phi)^2 - \frac{1}{2g(\phi)^2} F^2 \right]$$

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- Magnetic WGC implies $g(r) = \gamma(r)\rho(r)^{\frac{1}{2}}$, with $\gamma > 1$
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Summary

- Weak Gravity Conjecture is motivated by bottom-up arguments
- Swampland Conjecture is motivated by String Theory
- We find evidence for the Swampland Conjecture from a purely bottom-up perspective using only classical gravity and assuming a form of the WGC holds
- The SC and WGC can be used to constrain large field inflation

Questions?