Starobinsky Inflation and the Swampland

Joaquin Masias

Workshop on Quantum Gravity, Strings and the Swampland,
Corfu, September 4th, 2024

Based on [2312.13210, D. Lüst, M. Scalisi, B. Muntz, **JM**]

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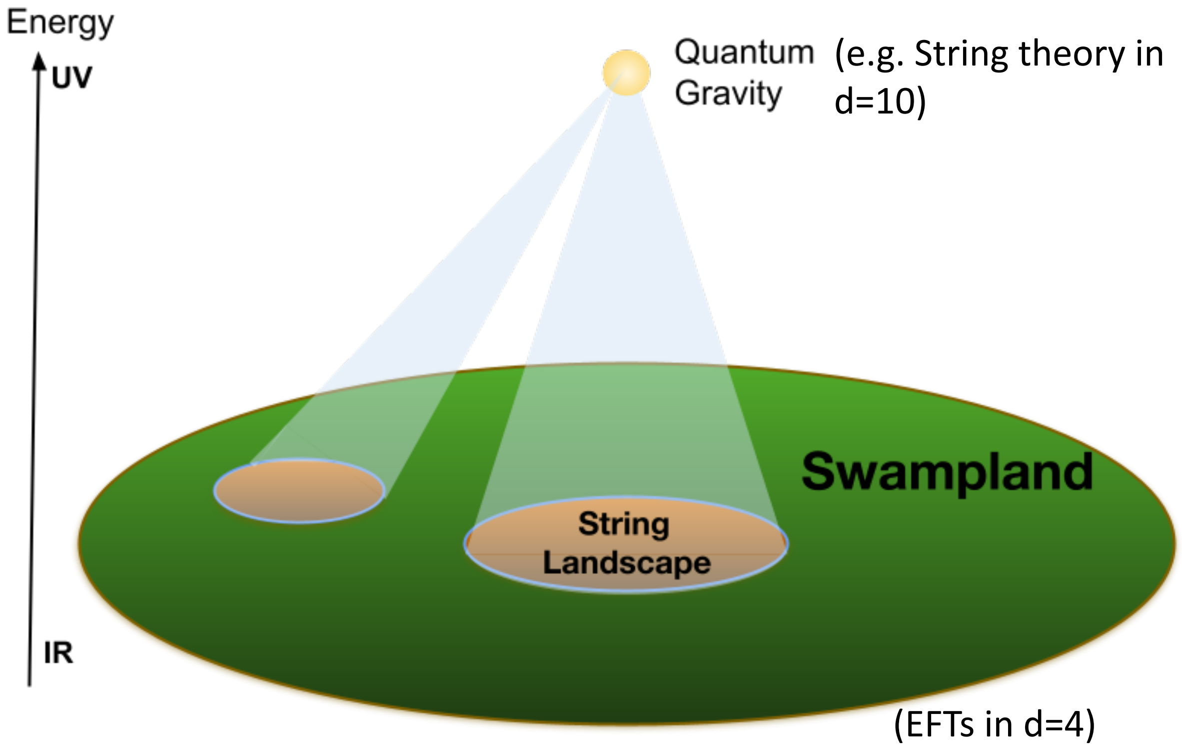

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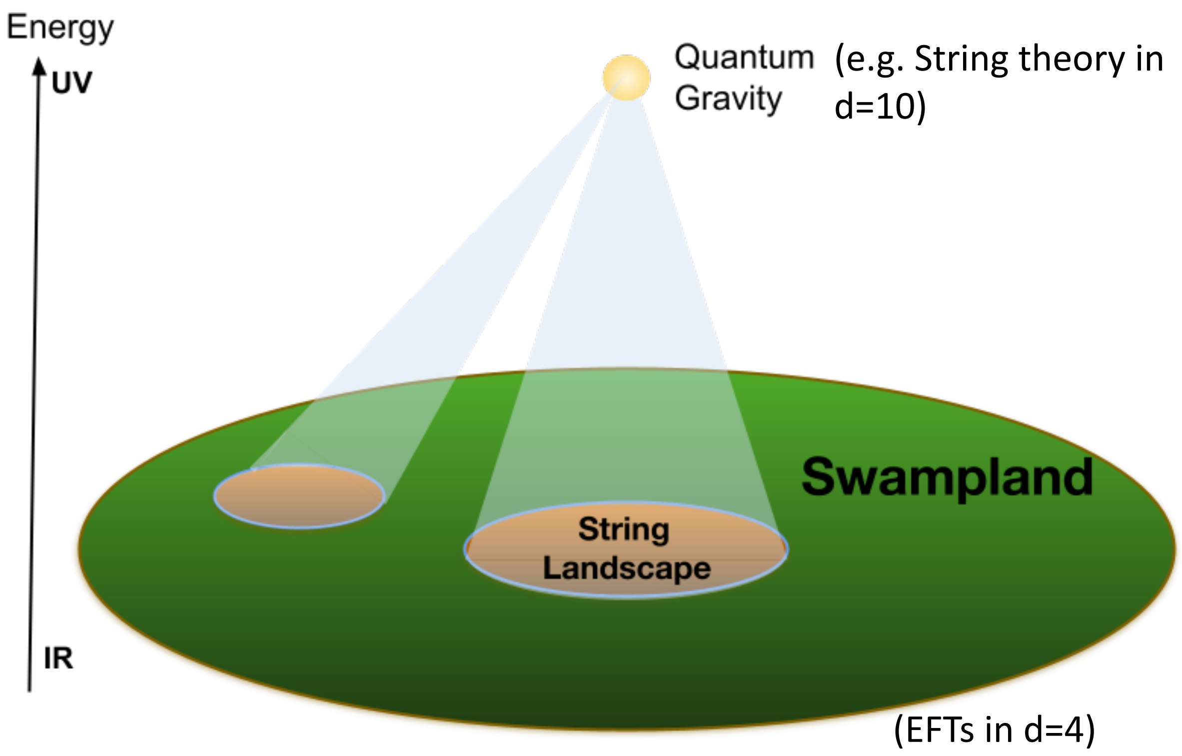

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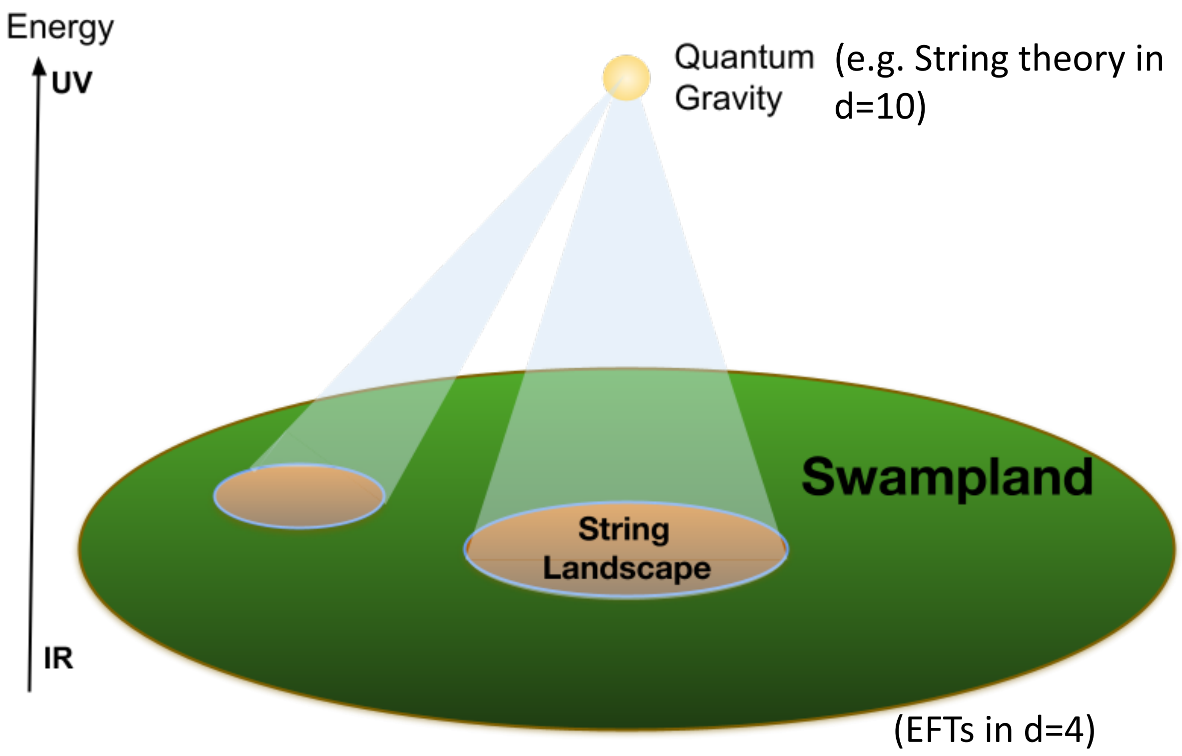
- The Swampland Program aims to determine general features of theories consistent with quantum gravity.



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$p \simeq \mathcal{O}(1)$ KK modes

$$\Lambda_{\rm sp} \simeq M_{{\rm Pl},\, d+p}$$

d+p dim Planck mass

$p \to \infty$ String excitations

$$\Lambda_{\rm sp} \simeq M_s$$

string scale

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- Hard to motivate from string theory, even harder to construct

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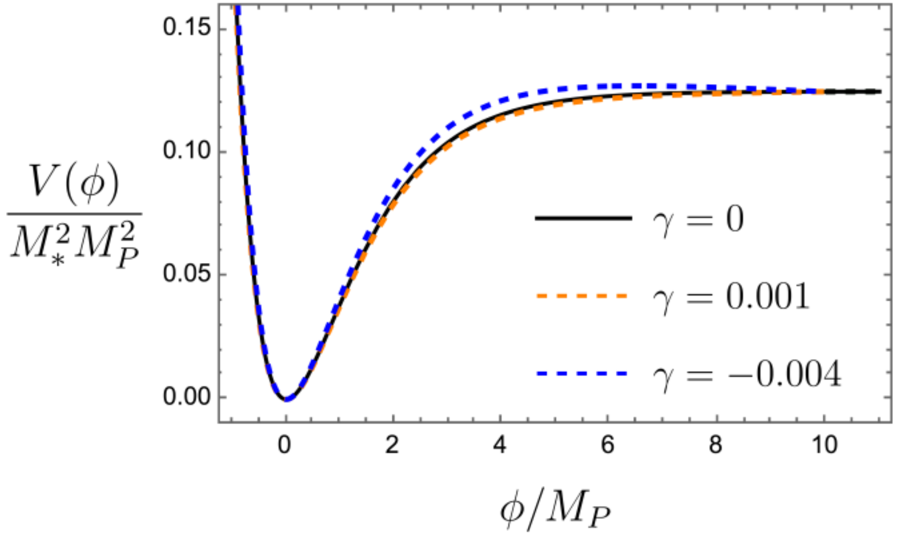

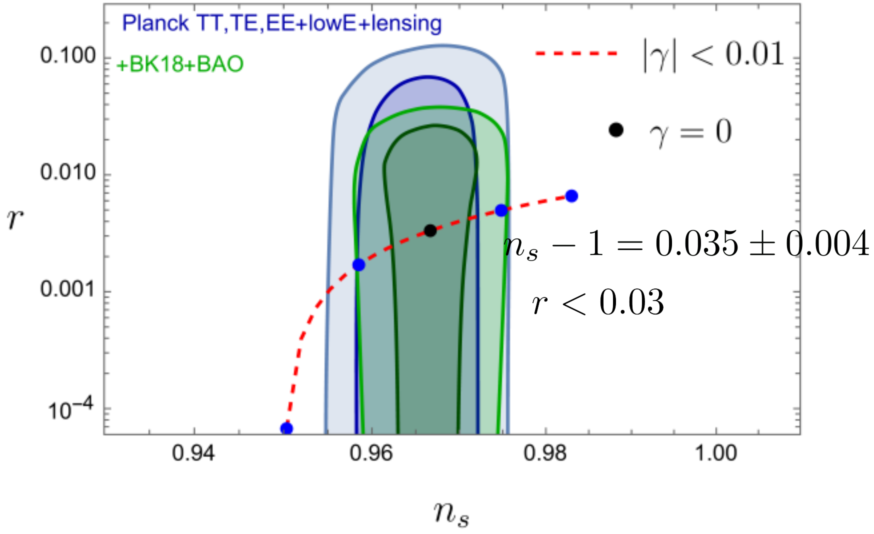

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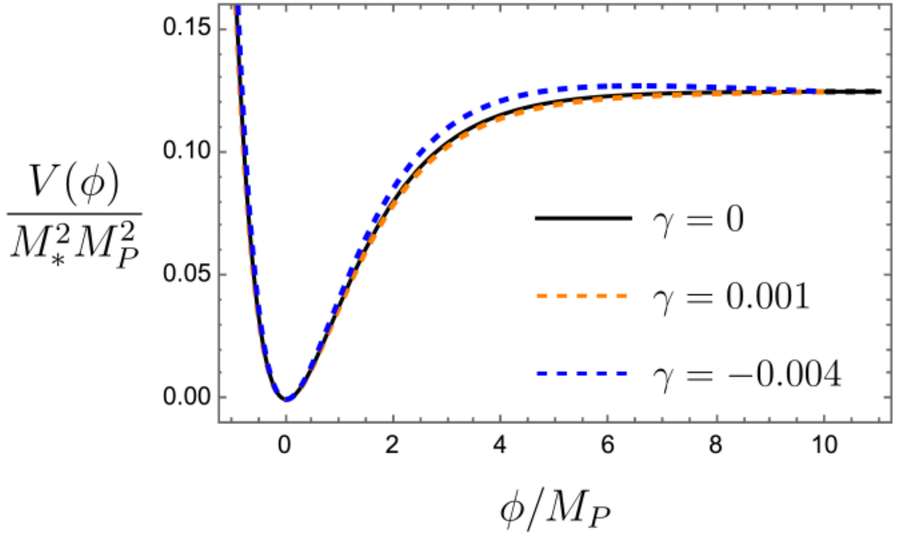

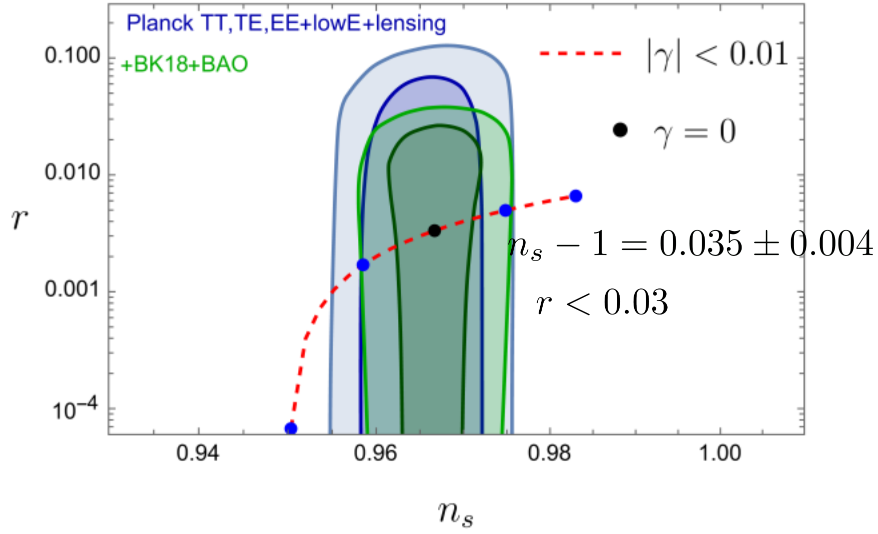

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$$n_s - 1 \simeq -\frac{2}{N_e} + 2\gamma\sqrt{\frac{2}{3}} + \mathcal{O}(\gamma^2)$$

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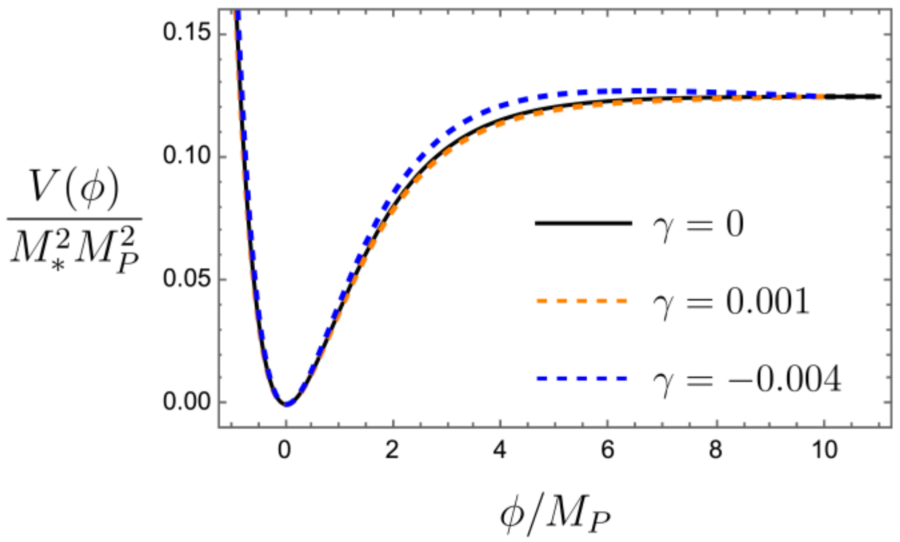

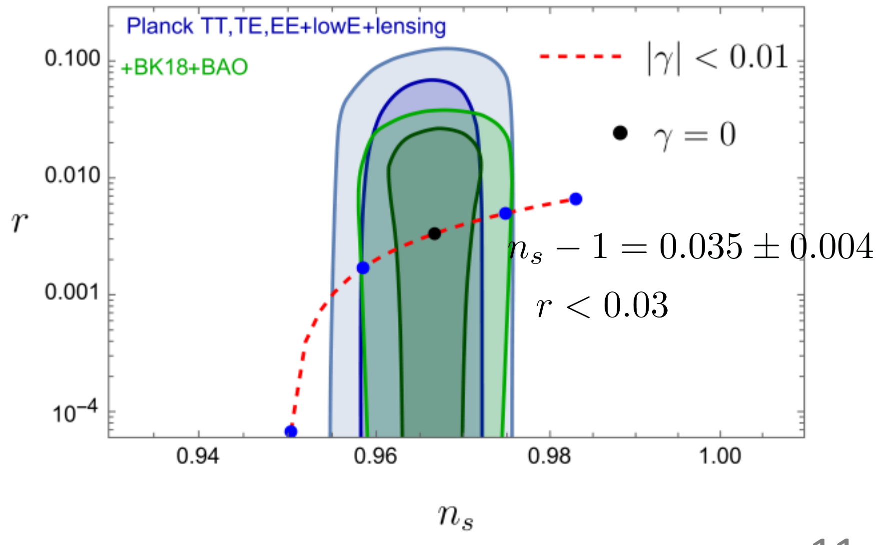

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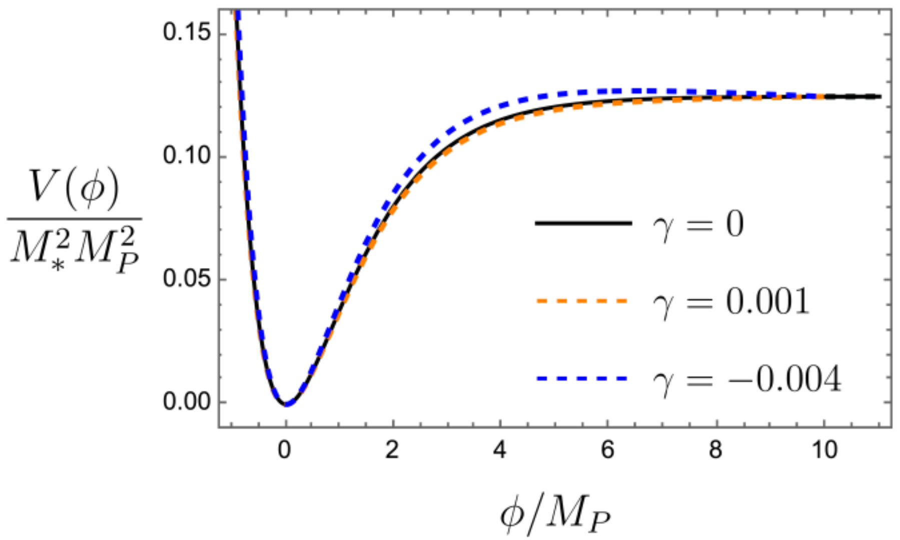

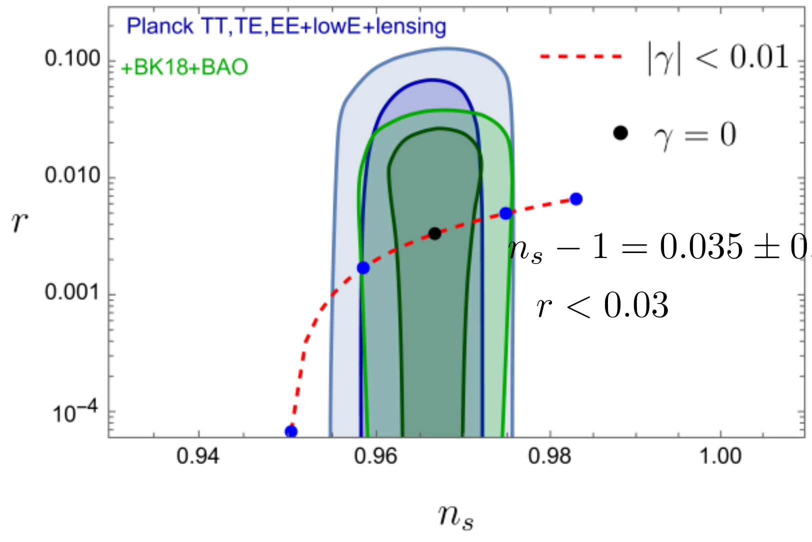

$n_s - 1 = 0.035 \pm 0.004$

$r < 0.03$

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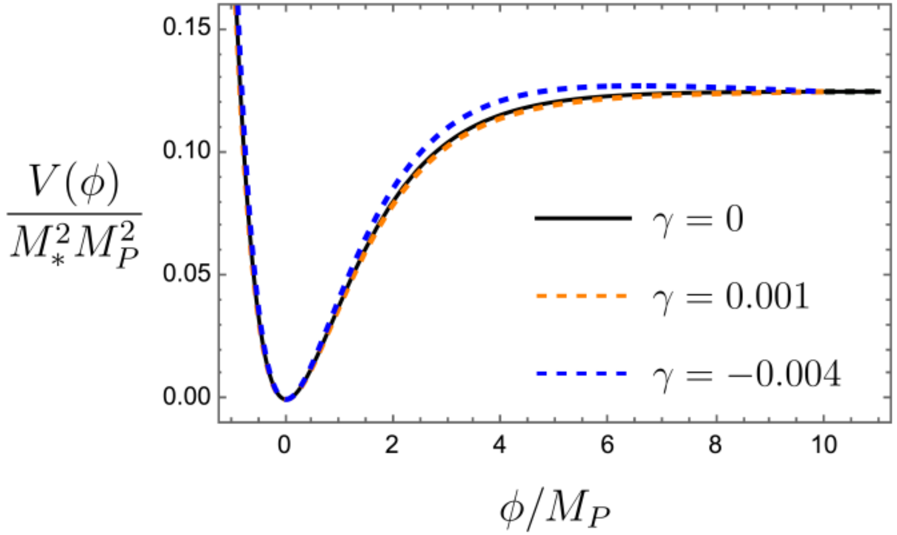

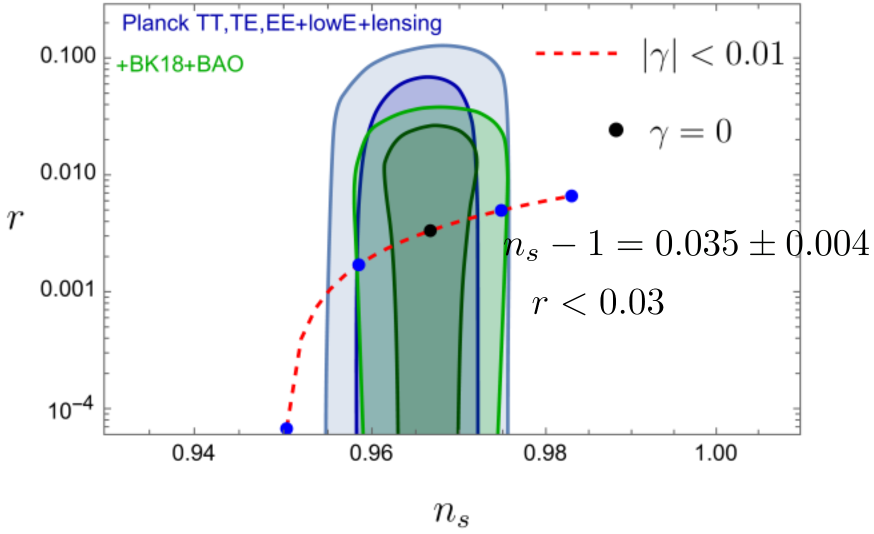

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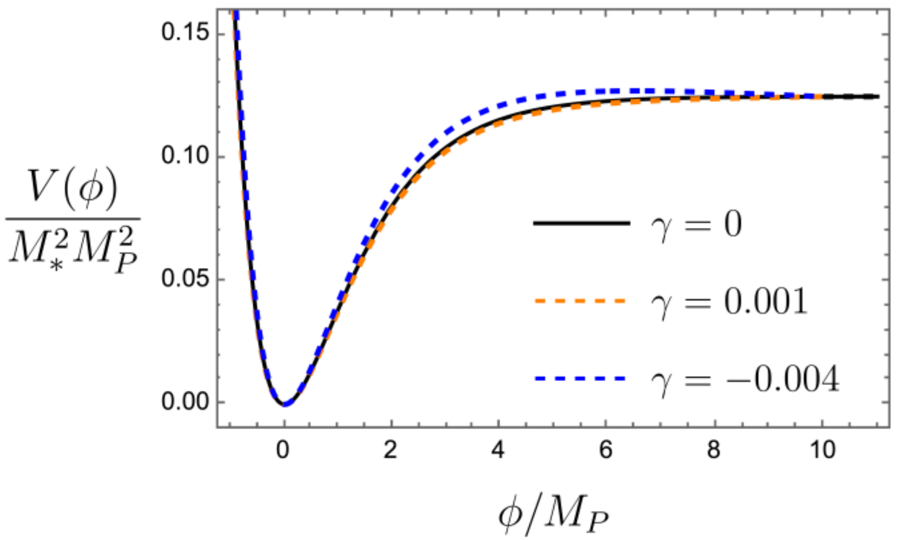
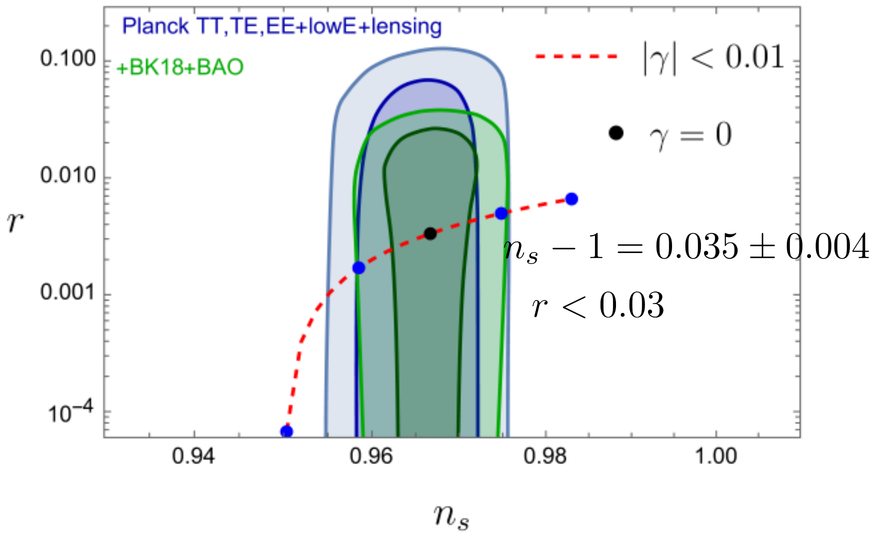
- Incompatible with expectations from the SDC



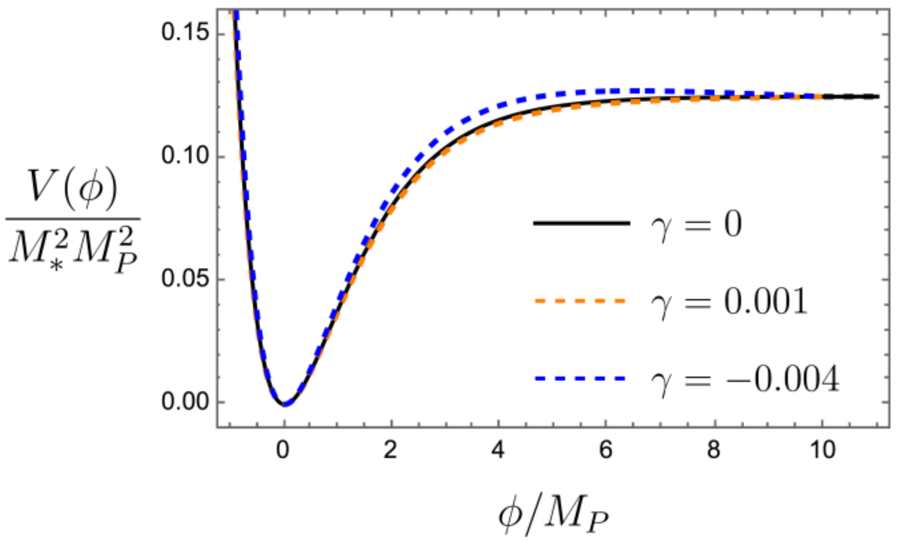


Inflationary Bounds

- The exponential scaling modifies the predictions of the model as

$$n_s - 1 \simeq -\frac{2}{N_e} + 2\gamma\sqrt{\frac{2}{3}} + \mathcal{O}(\gamma^2)$$

$$r \simeq \frac{12}{N_e^2} + \gamma\frac{8\sqrt{6}}{N_e} + \mathcal{O}(\gamma^2)$$



- Satisfying experimental bounds requires

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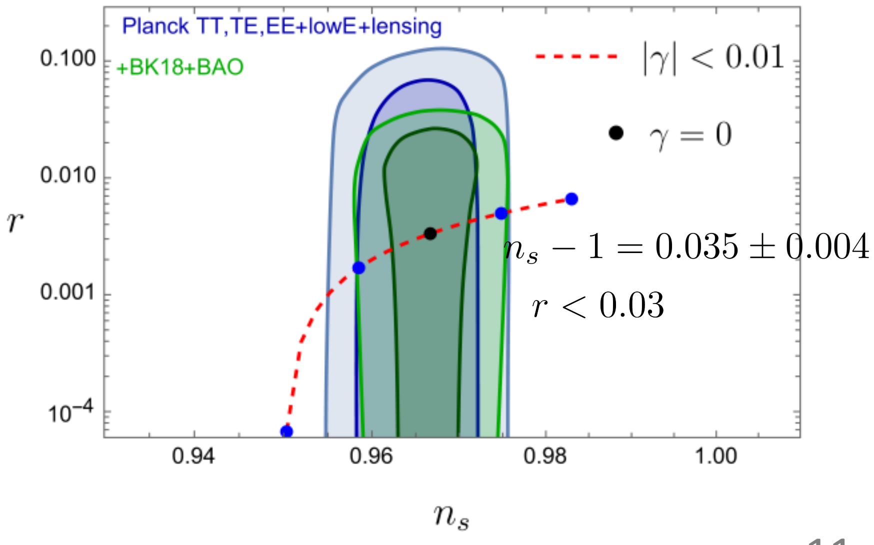

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$$\gamma = \frac{\Lambda_s'}{\Lambda_s} \qquad\qquad \frac{1}{\sqrt{6}} \leq \left|\frac{\Lambda_s'}{\Lambda_s}\right| \leq \frac{1}{\sqrt{2}}$$

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$$S_{\rm het} \sim \frac{M_s^8}{g_s^2}\mathcal{V}_s\ell_s^6\int d^4x\,\sqrt{-g_4^{(E)}}\left[R_4 + \alpha' R_4^2 + \cdots\right]\,.$$

$$S_{\rm IIB} \sim M_{P,4}^2\int d^4x\,\sqrt{-g_4^{(E)}}\left[R_4 + g_s^{-2}\mathcal{V}_s^{1/3}\frac{R_4^2}{M_{P,4}^2} + \cdots\right]\,.$$

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- Not protected from higher curvature corrections!

Conclusions

- The Starobinsky model of inflation can be interpreted as a QG correction to EH gravity.
- In particular, it can be generated by the renormalization effects of a tower of light species.
- Top-down arguments can be used to identify $M \simeq \Lambda_s$.
- Identifying $M \simeq \Lambda_s$, leads to $\Lambda_s \simeq 10^{14}$ GeV, $N_{sp} \simeq 10^{10}$.
- Starobinsky Inflation is spoiled by an exponential scaling $|\gamma| \gtrsim \mathcal{O}(10^{-3})$.