New Horizons in the Holographic Conformal Phase Transition

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Elevator pitch

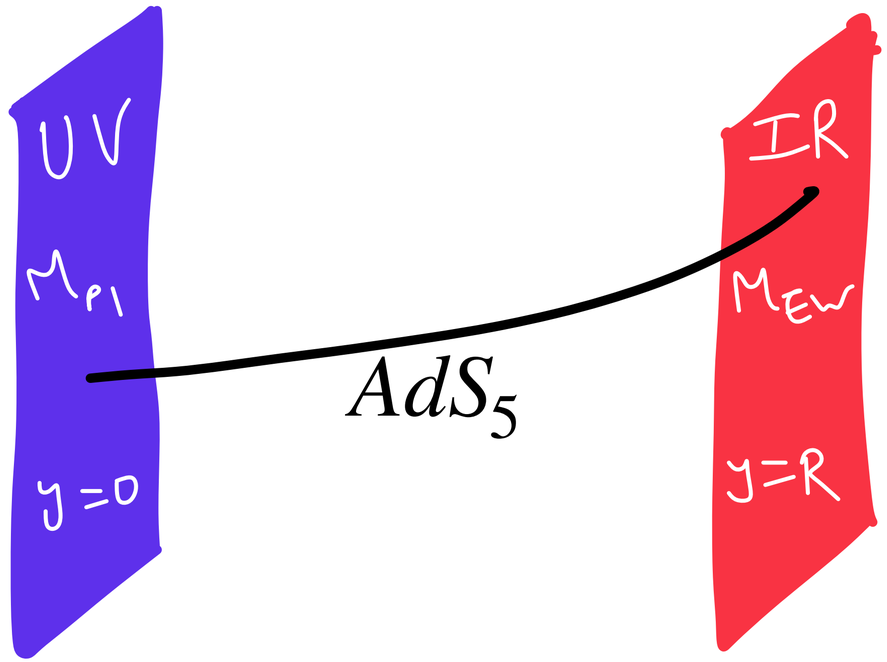
We have created an out of equilibrium dynamical cosmological solution to the stabilized holographic dilaton and demonstrated a large class of initial conditions that lead to prompt completion of the conformal phase transition without sacrificing perturbativity.

Introduction

RS-I ($T = 0$)

$$ds^2 = e^{-2A(y)}(dt^2 - d\vec{x}^2) - dy^2$$

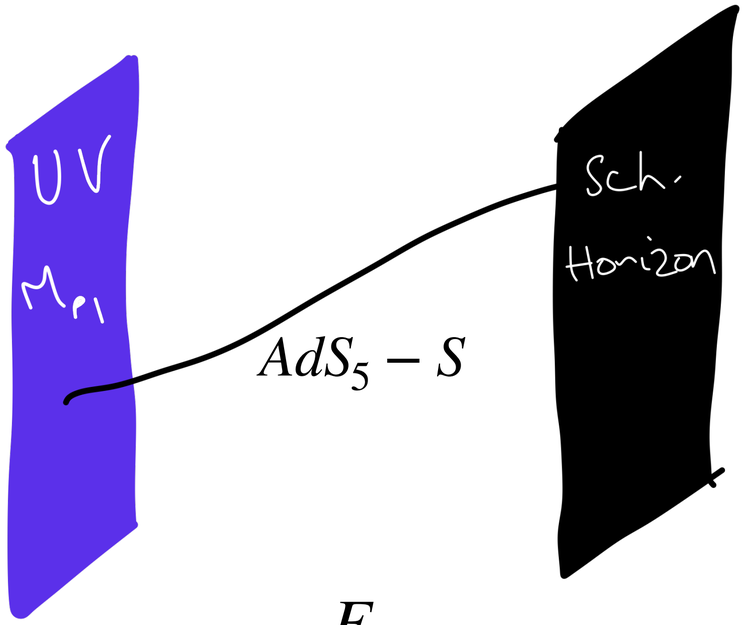
- Geometric solution to hierarchy problem
- Dual to spontaneously broken CFT on the boundary
- IR scale: $f = ke^{-kR}$
- Stabilizing mechanism to avoid fine-tuning of both brane tensions
- Goldberger-Wise mechanism: $\phi(y)$- source of CFT breaking, generates $V_{\text{eff}}(R)$ minimized at correct R.
- Brane tensions now dynamically varying quantities
- Remaining fine tuning sets 4D CC

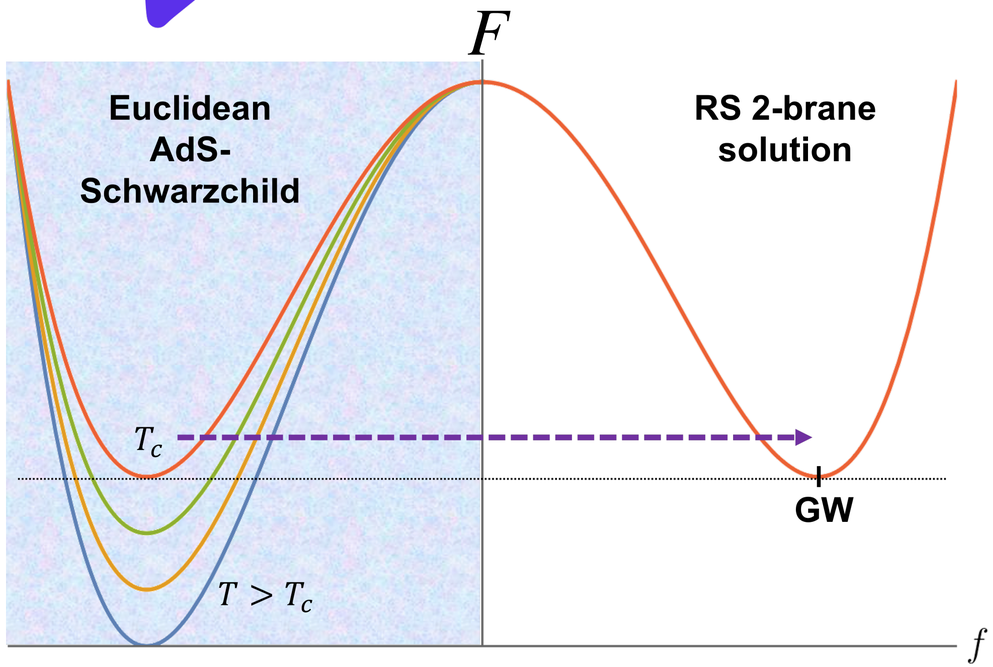


Introduction

RS ($T \gg f$) and the phase transition

- Dual to unbroken CFT at finite T
- PT to RS-I phase strongly first order
- CFT in eqlm with dark radiation plasma
- Bubble nucleation does not finish
- $\frac{\Gamma}{V} \sim e^{-S_b} \propto e^{-\frac{1}{\kappa^2}}$
- Universe stuck in eternal inflation
- PT important to understand



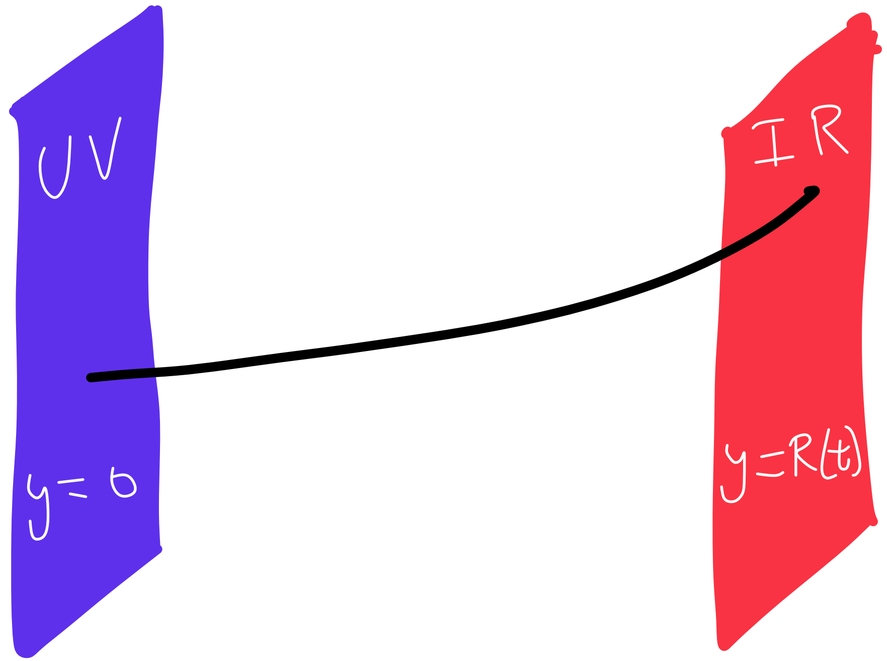


Dynamical Cosmology

$$ds^2 = n^2(y,t)dt^2 - a^2(y,t)d\vec{x}^2 - dy^2$$

- Pure gravity in bulk
- Tensions on brane $T_{0,1} = \pm \frac{6k}{\kappa^2}(1 \pm \delta_{0,1})$

CFT language:
$\delta_0 \equiv$ CC that gaps CFT
$\delta_1 \equiv$ dimensionless dilaton quartic



moving through the bulk

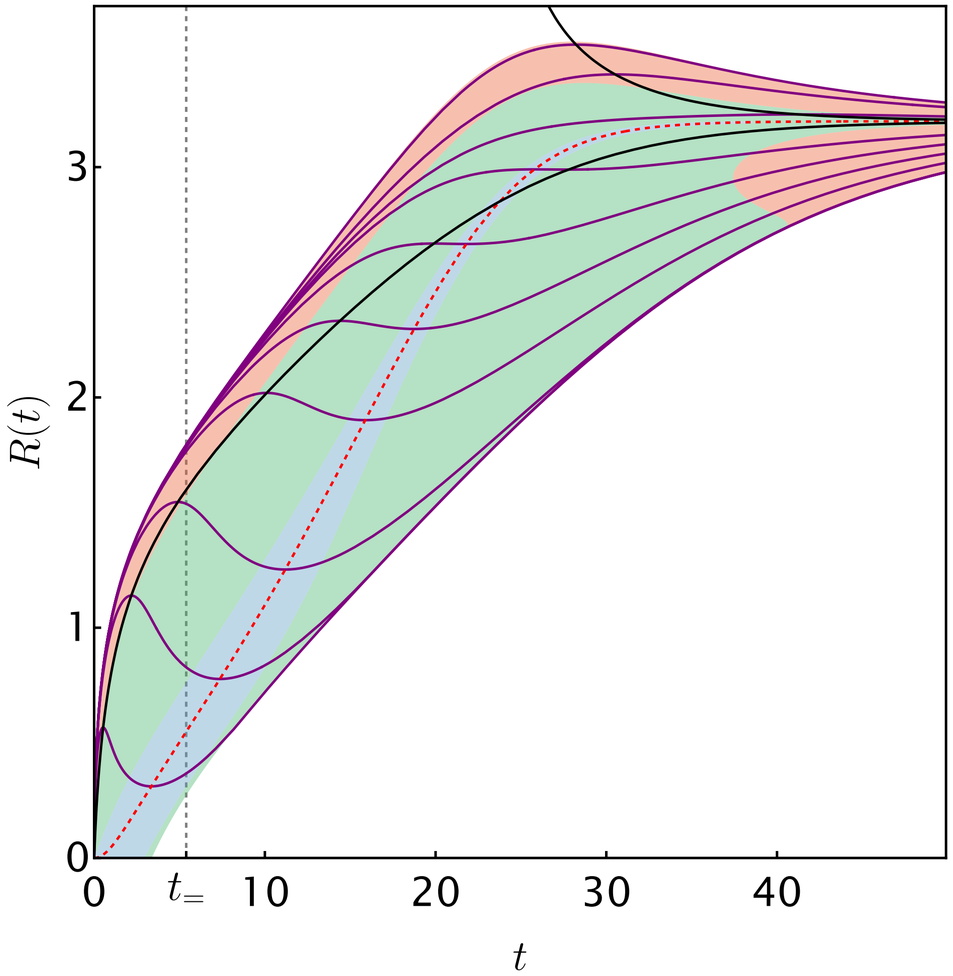
$$\frac{1}{k^2}\bar{H}^2 = \frac{4\lambda}{\bar{a}^4} + \delta_0(2+\delta_0)$$

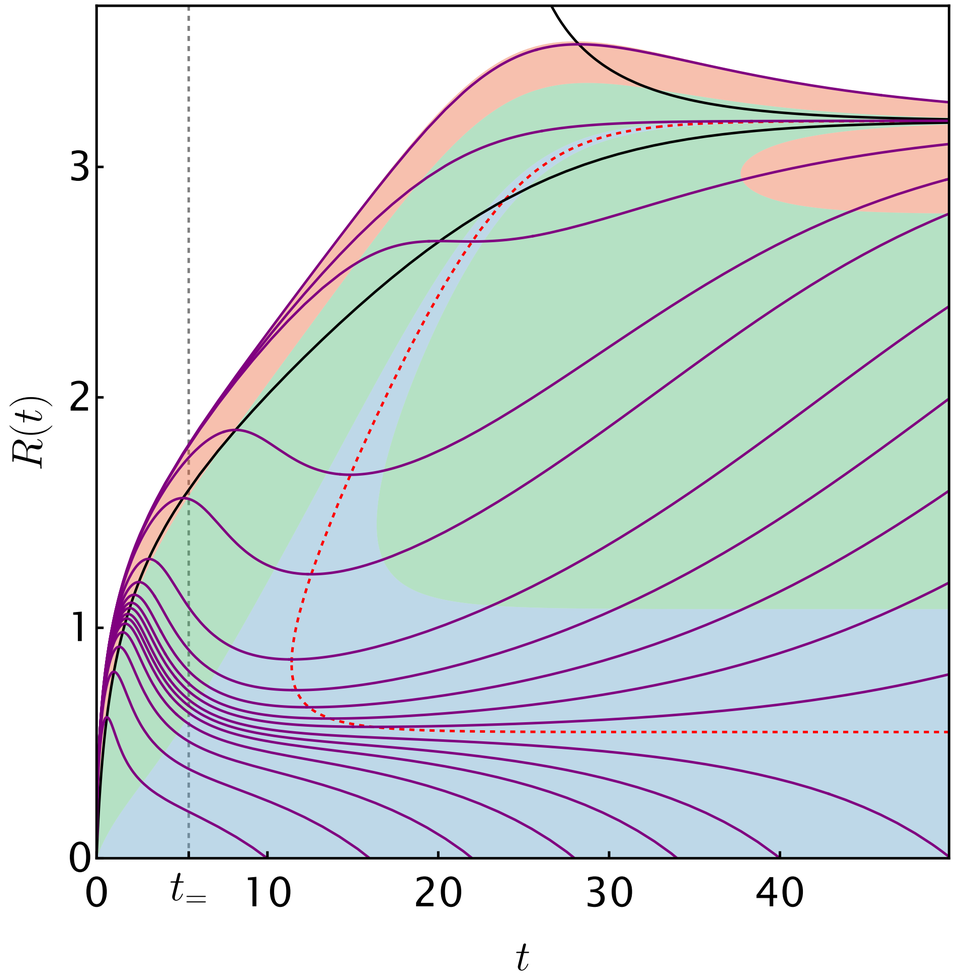
Unstabilized Cosmology ($\delta_0 > 0$)

$\delta_1 > 0$

$$T = \frac{k}{\pi} e^{-y_h}$$

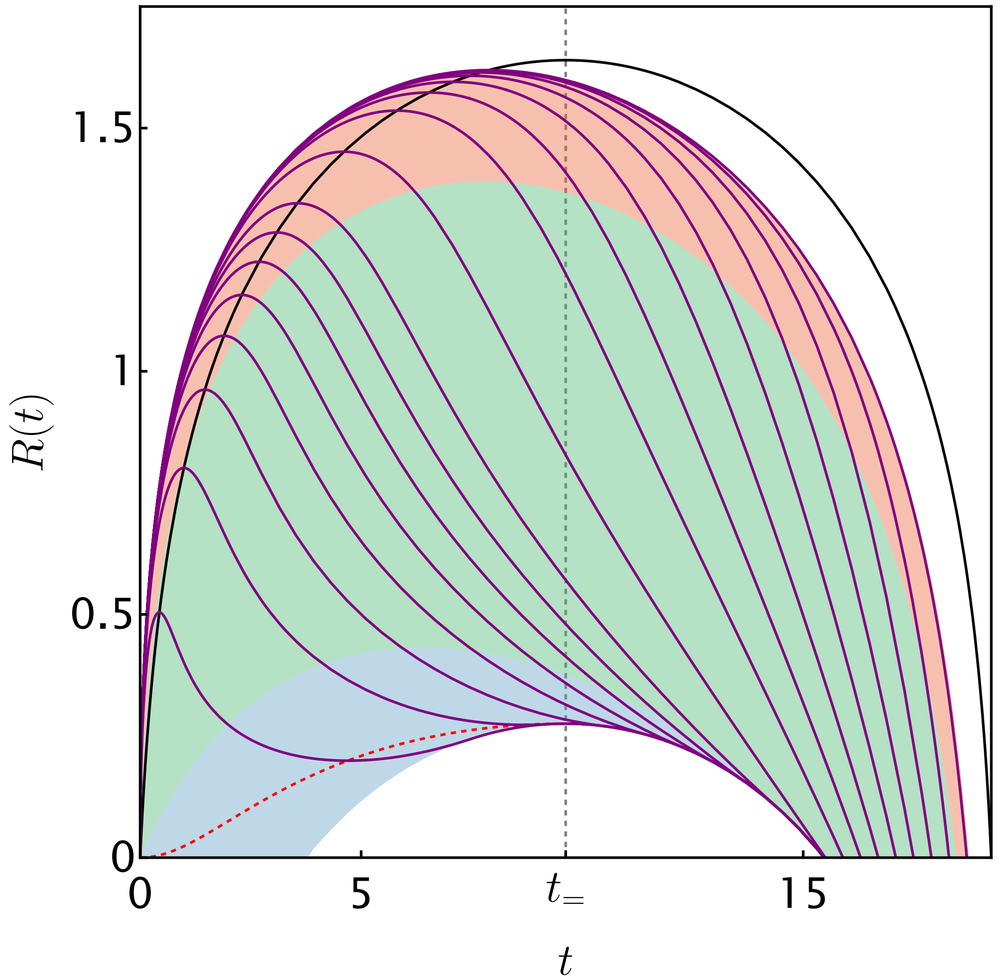
$\delta_1 < 0$



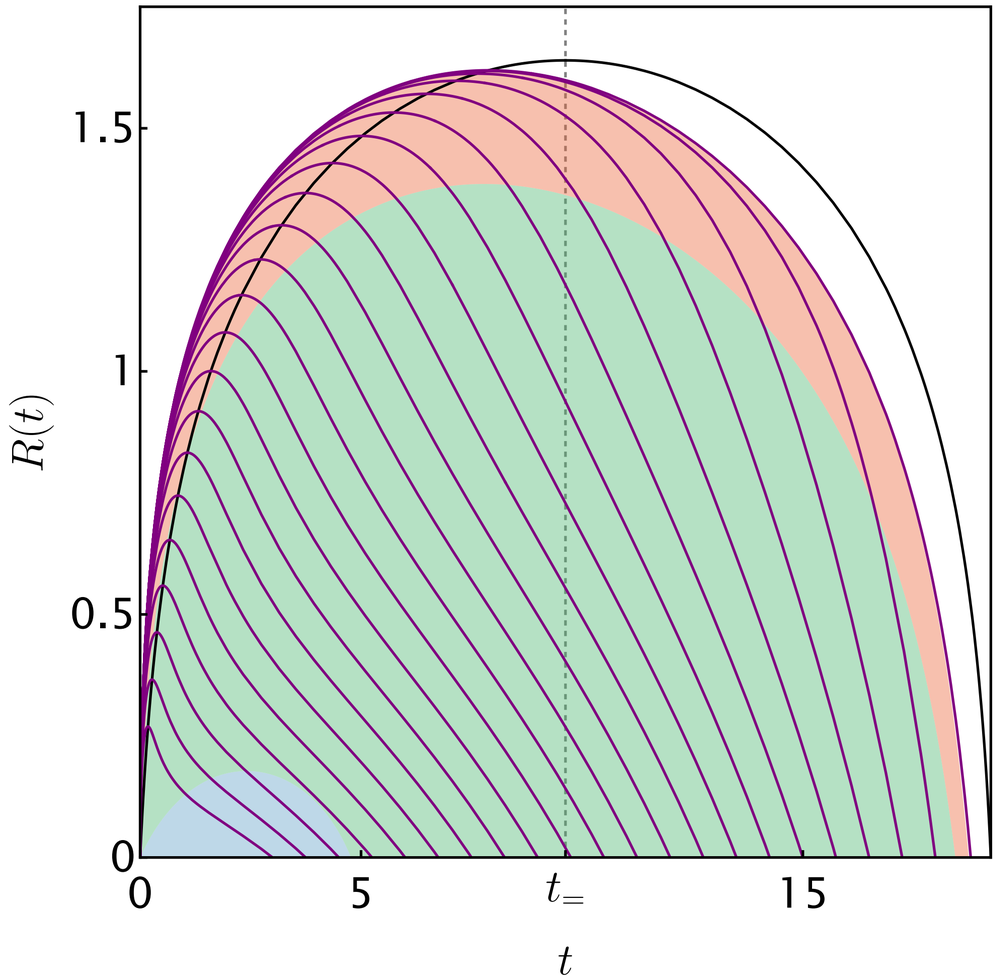


Unstablized Cosmology ($\delta_0 < 0$)

$\delta_1 > 0$

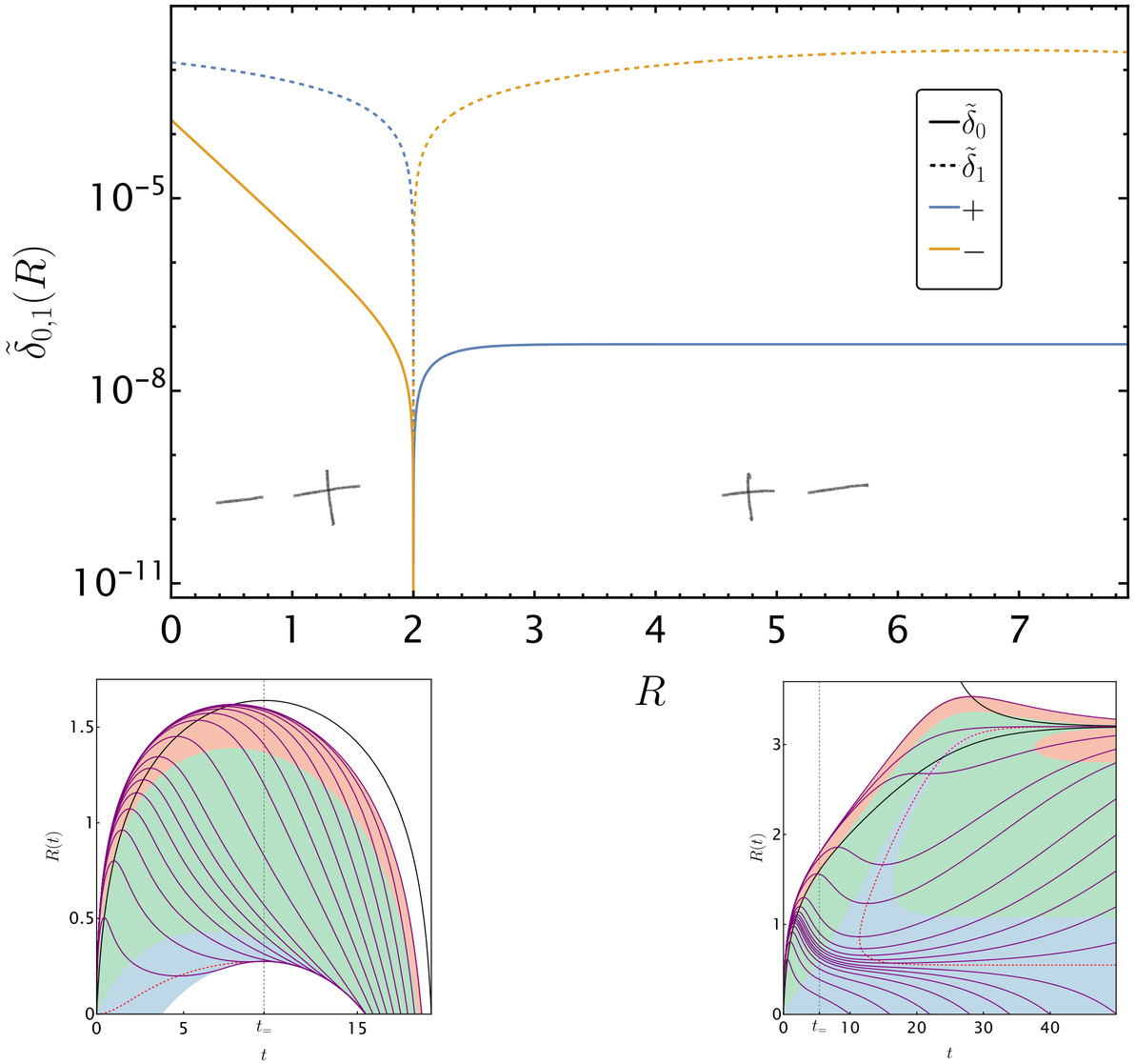


$\delta_1 < 0$

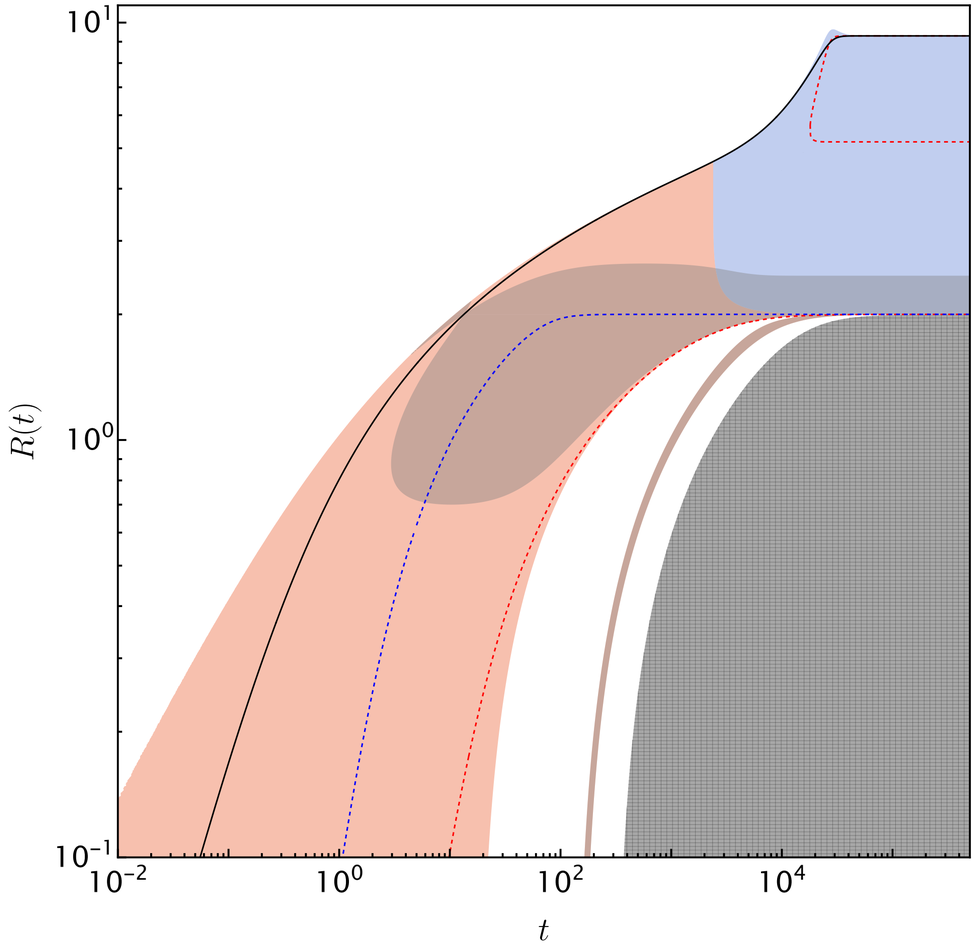


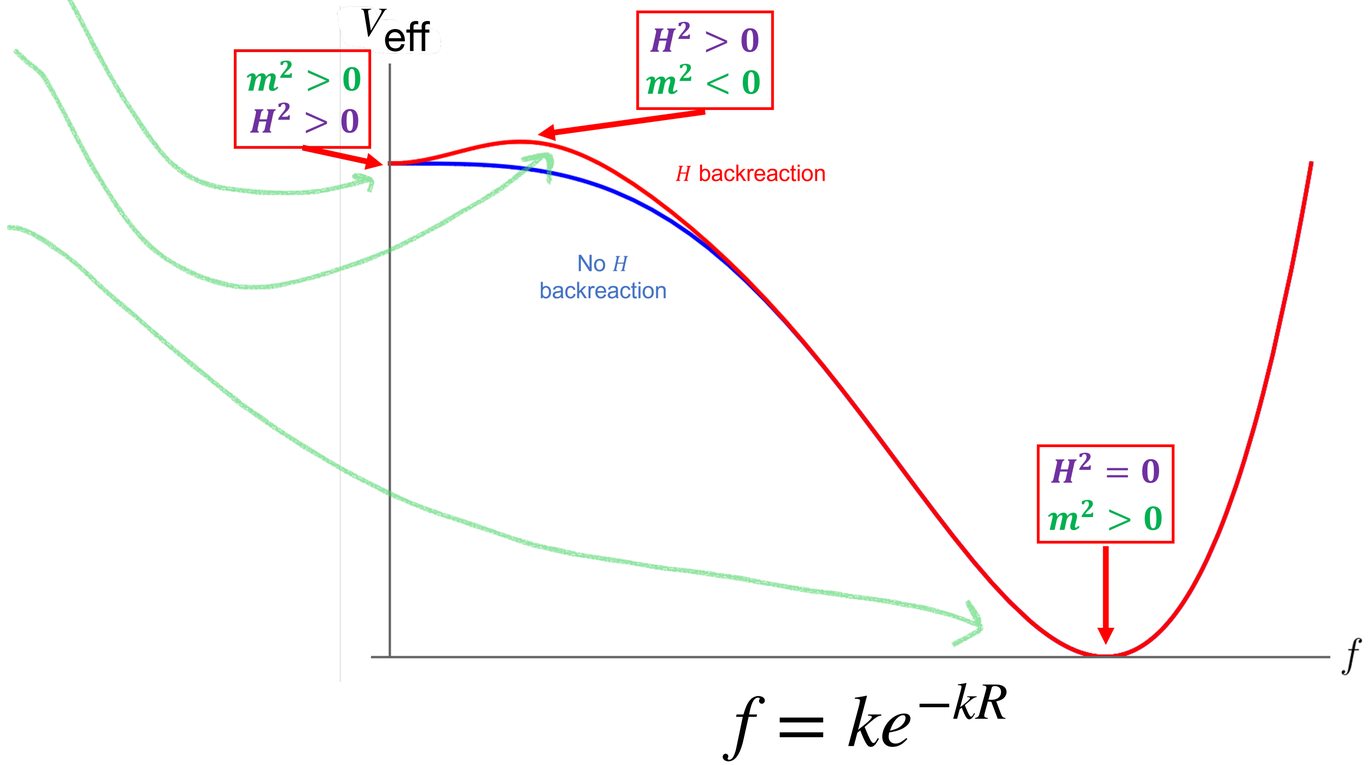
Stabilized Cosmology

- Typically difficult because $\phi(y,t)$.
- Good approximation: $\phi(y,R(t))$
- Yields slowly rolling $\tilde{\delta}_{0,1}(R)$ with $\tilde{\delta}_{0,1}(\bar{R})=0$
- UV observer: $\frac{1}{k^2}\bar{H}^2=\frac{4\lambda}{\bar{a}^4}+\tilde{\delta}_0(2+\tilde{\delta}_0)$
- Brane EoM: $\ddot{R}+3\hat{H}\dot{R}+\frac{\partial V_{\text{eff}}}{\partial R}=0$



Stabilized Cosmology picture



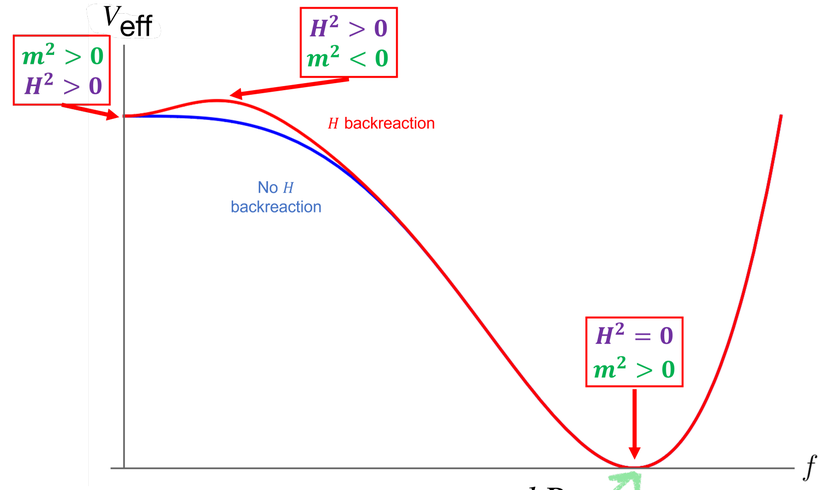


$$f = ke^{-kR}$$

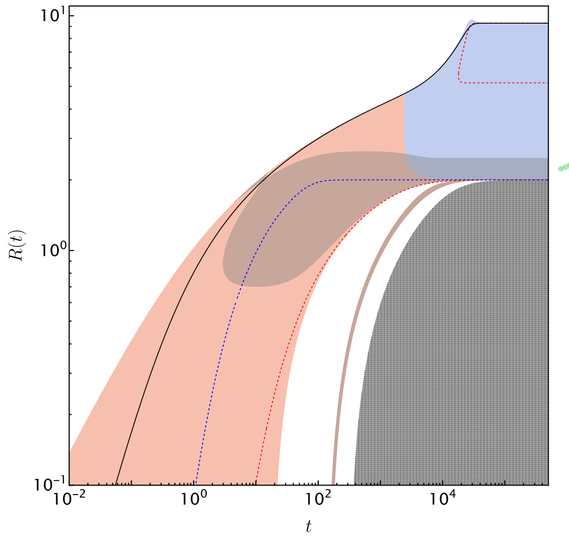
Fate of the Universe

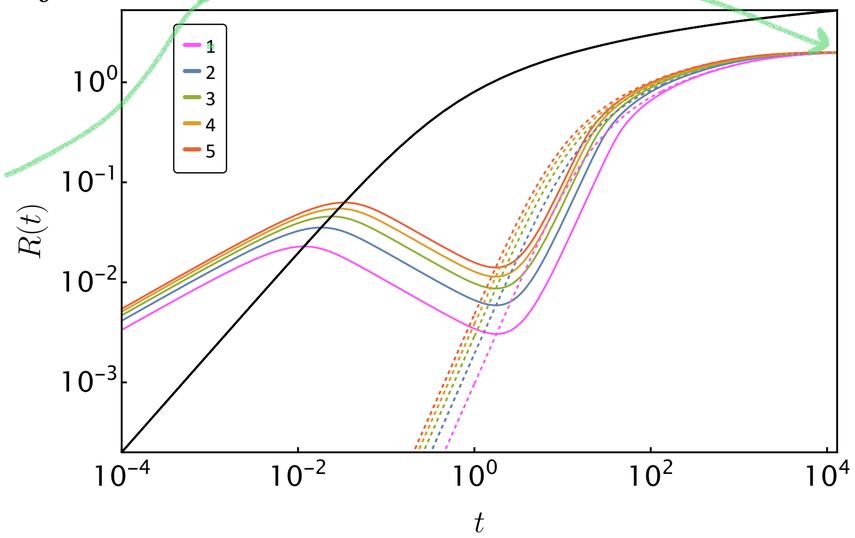
Where does the cosmology put the IR brane?

- Phenomenological parameters need $\gamma \sim \mathcal{O}(10^4)$ for IR brane at early times to make it to the meta-stable minimum
- Requires huge disparity in partition of energy at early times
- For more equitable partitions, $\gamma \sim \mathcal{O}(1)$, and the universe robustly ends up at the global minimum without a strongly first order phase transition, well within the comfort of perturbativity



$f = ke^{-kR}$





Thank you

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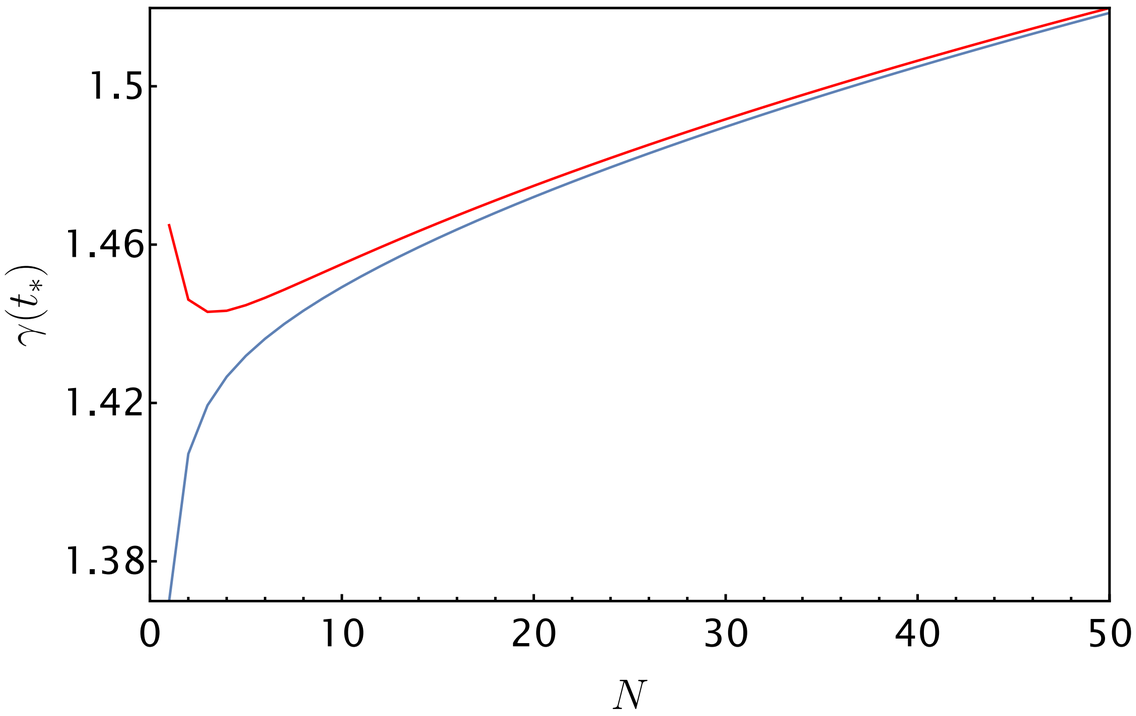
Initial Conditions

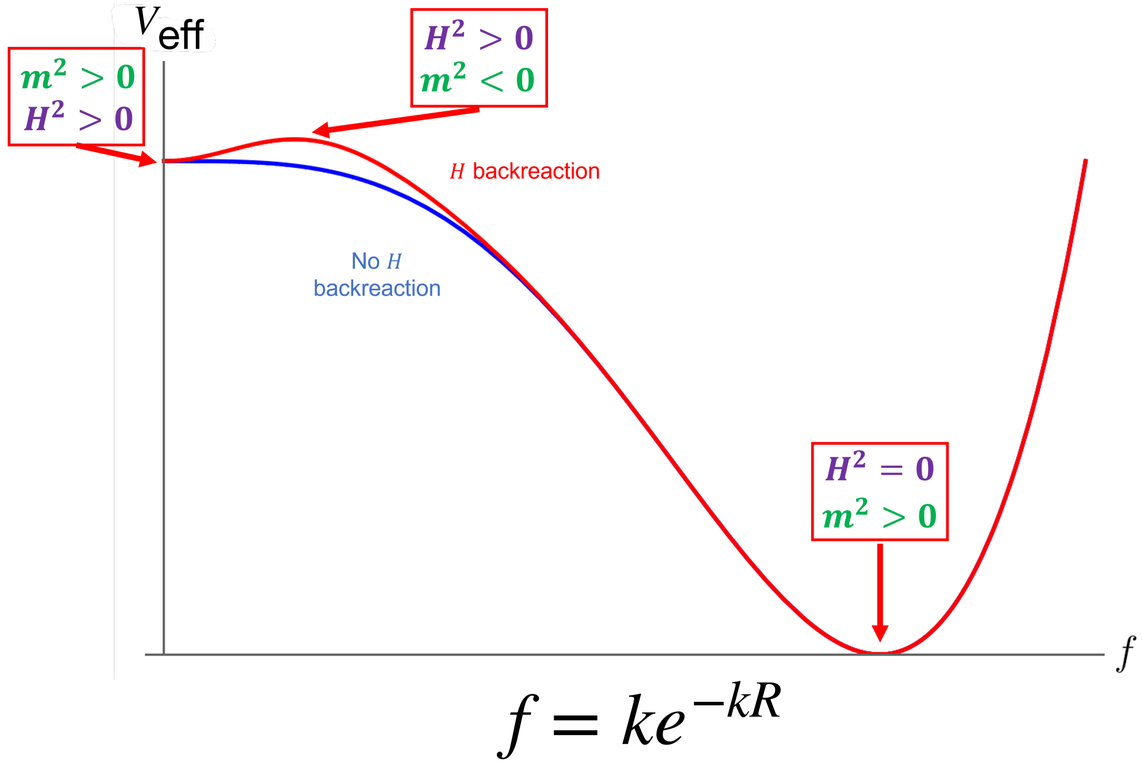
- Say early dynamics didn't discriminate between dofs
- Equipartition of energies:
- $\rho_{\text{dilaton}} \sim \frac{1}{N^2}\rho_R$
- $$\left|\frac{a^3 n}{\bar{a}^3}\right| \gamma(t_*) = \frac{1}{720\tau_0^2}\left(\frac{3\pi^2}{2}\right)^{1/3} N^{-4/3}$$



Late-time scalar solutions

$$\ddot{R} + 3\hat{H}\dot{R} + \frac{\partial V_{\text{eff}}}{\partial R} = 0$$

Late-time limit of V_{eff}



$$f = ke^{-kR}$$

Scalar solution