Geometrical destabilization and reheating

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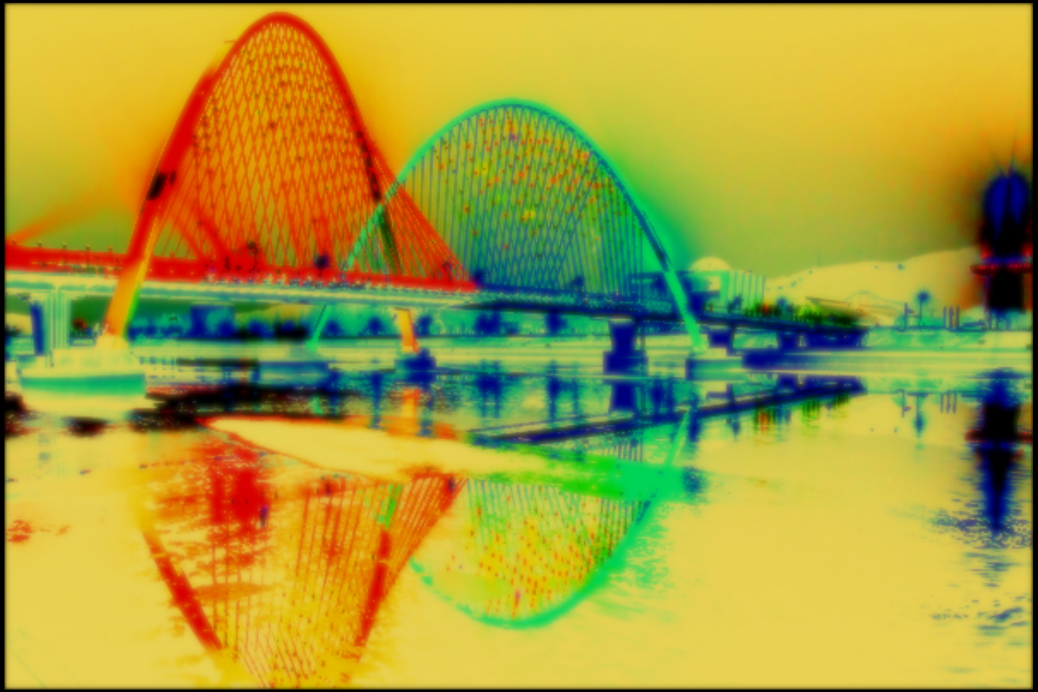

arXiv:1801.01786

with Tomasz Krajewski
and Michał Wieczorek

COSMO-18

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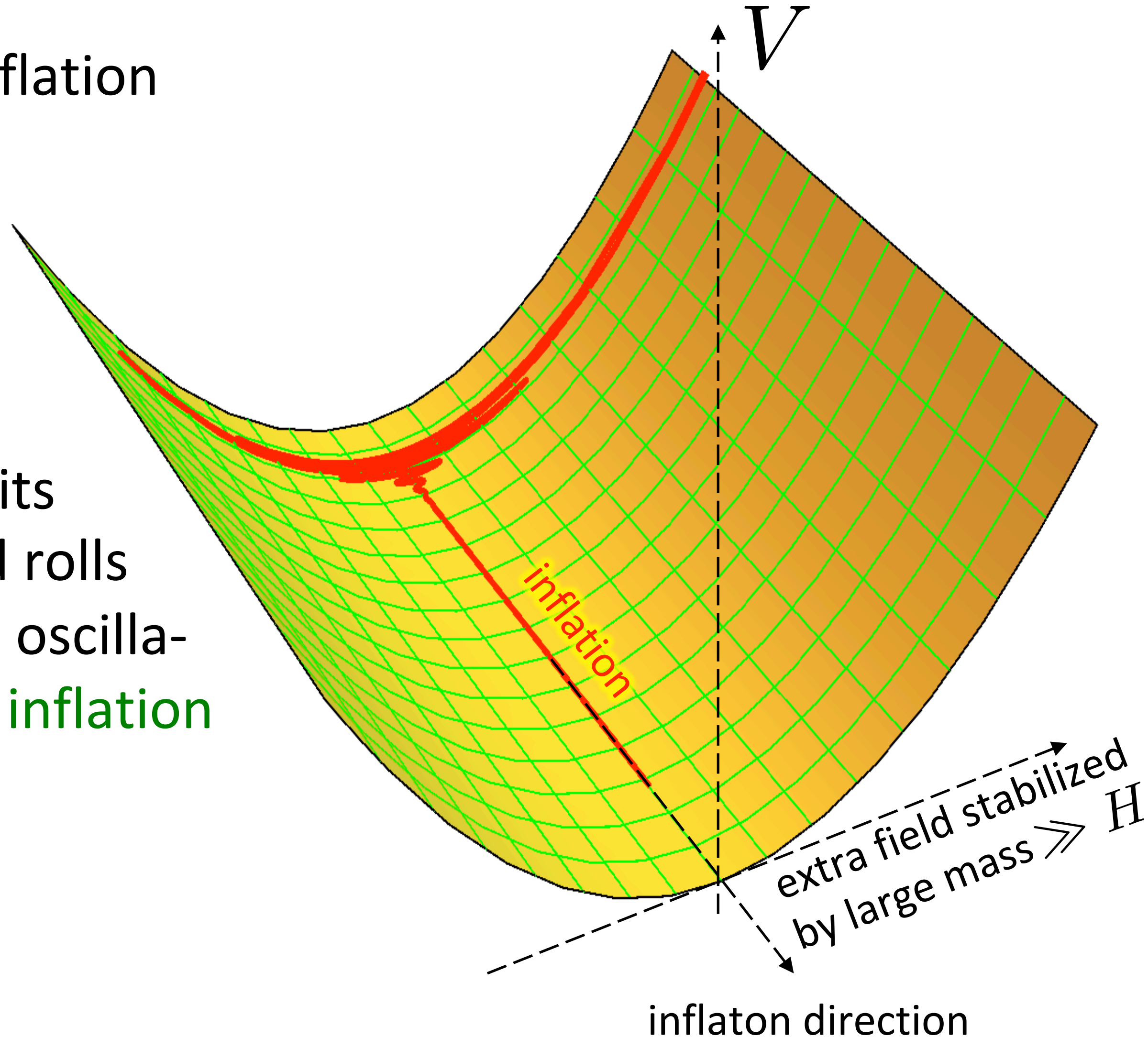
Daejeon, Korea

Inflation and heavy fields

- one light field drives inflation
- other fields are heavy and completely decouple from the low-energy EFT governing inflation
- even if displaced from its minimum, the heavy field rolls back performing damped oscillations and does not affect inflation



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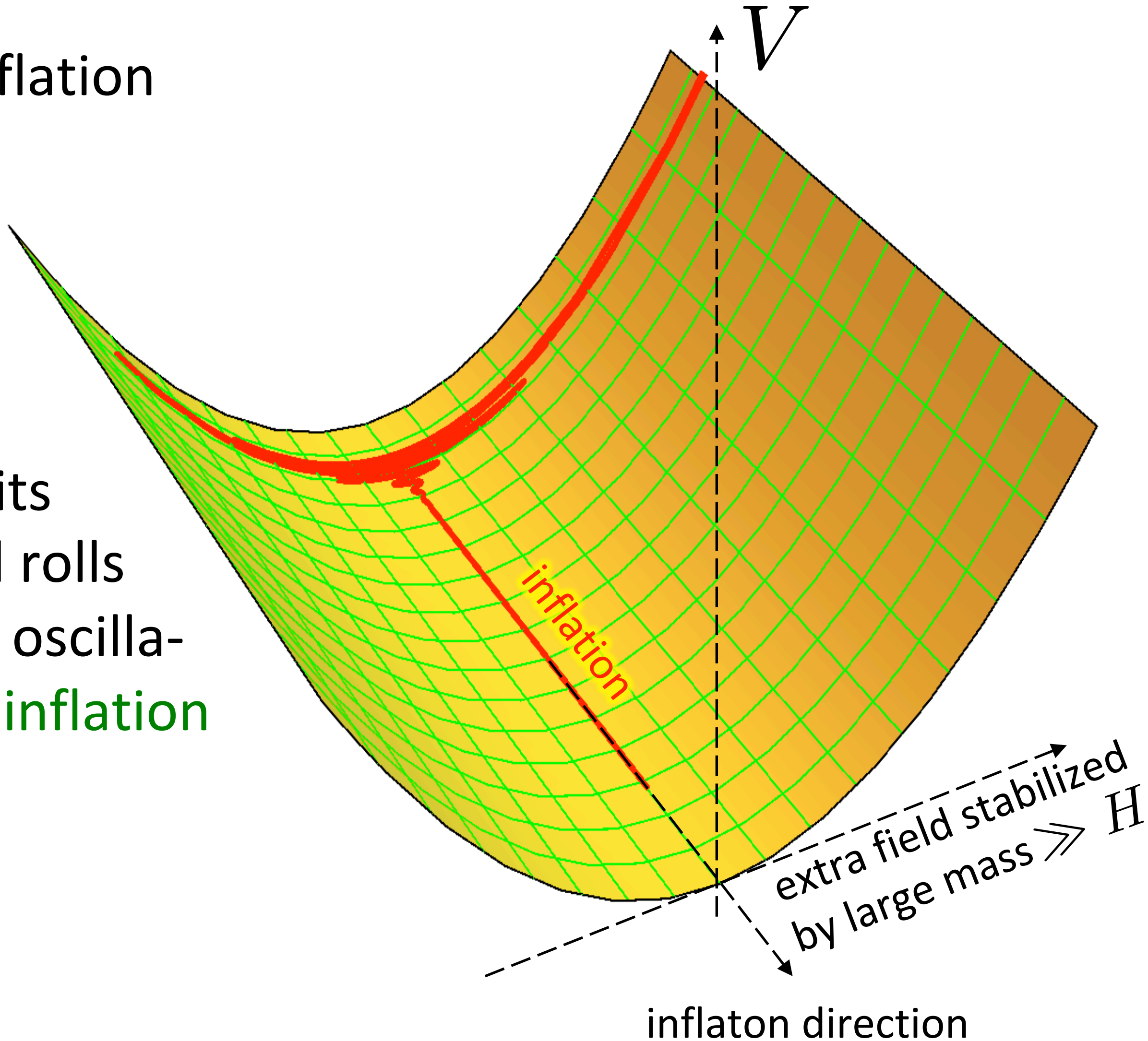

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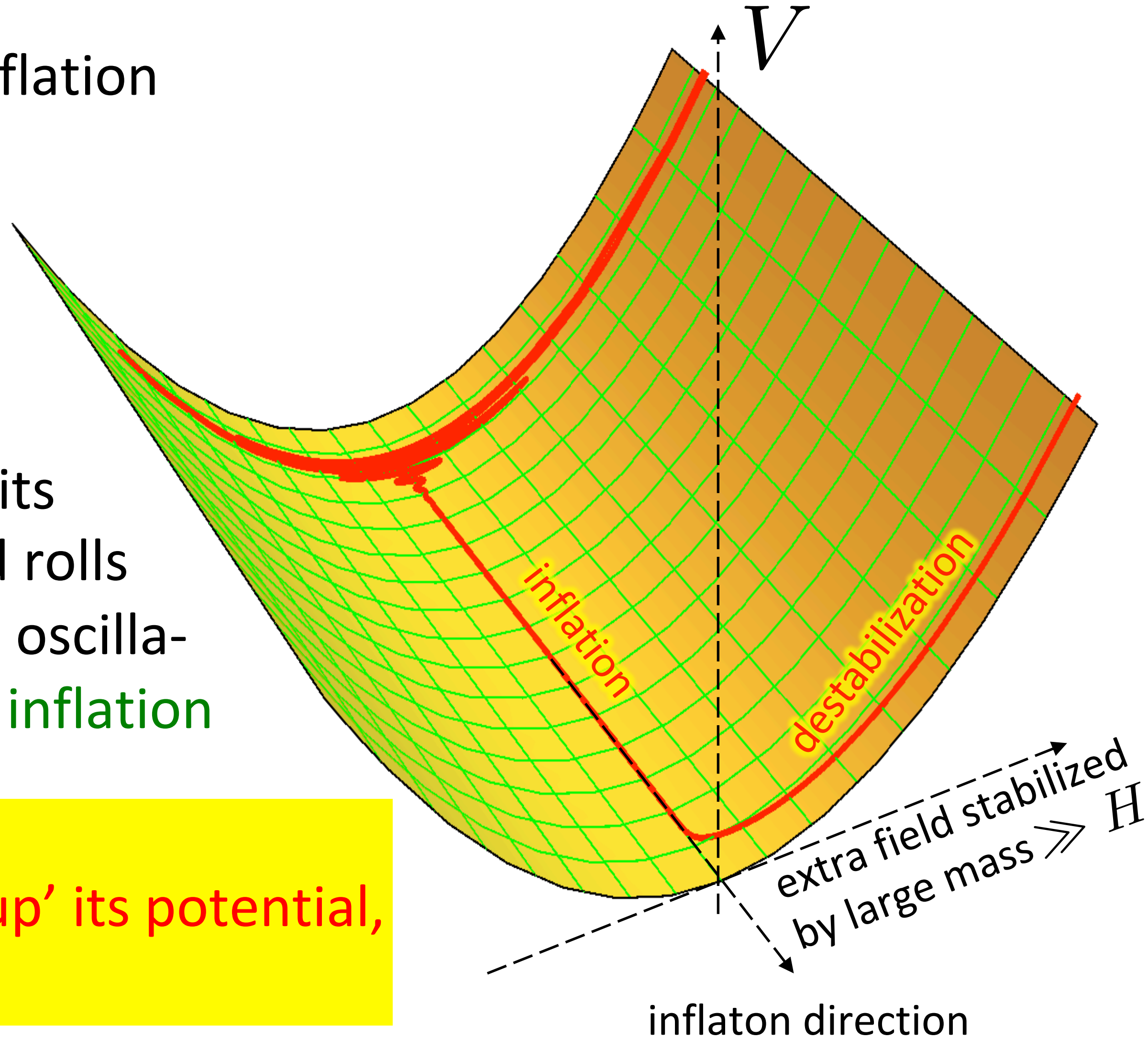
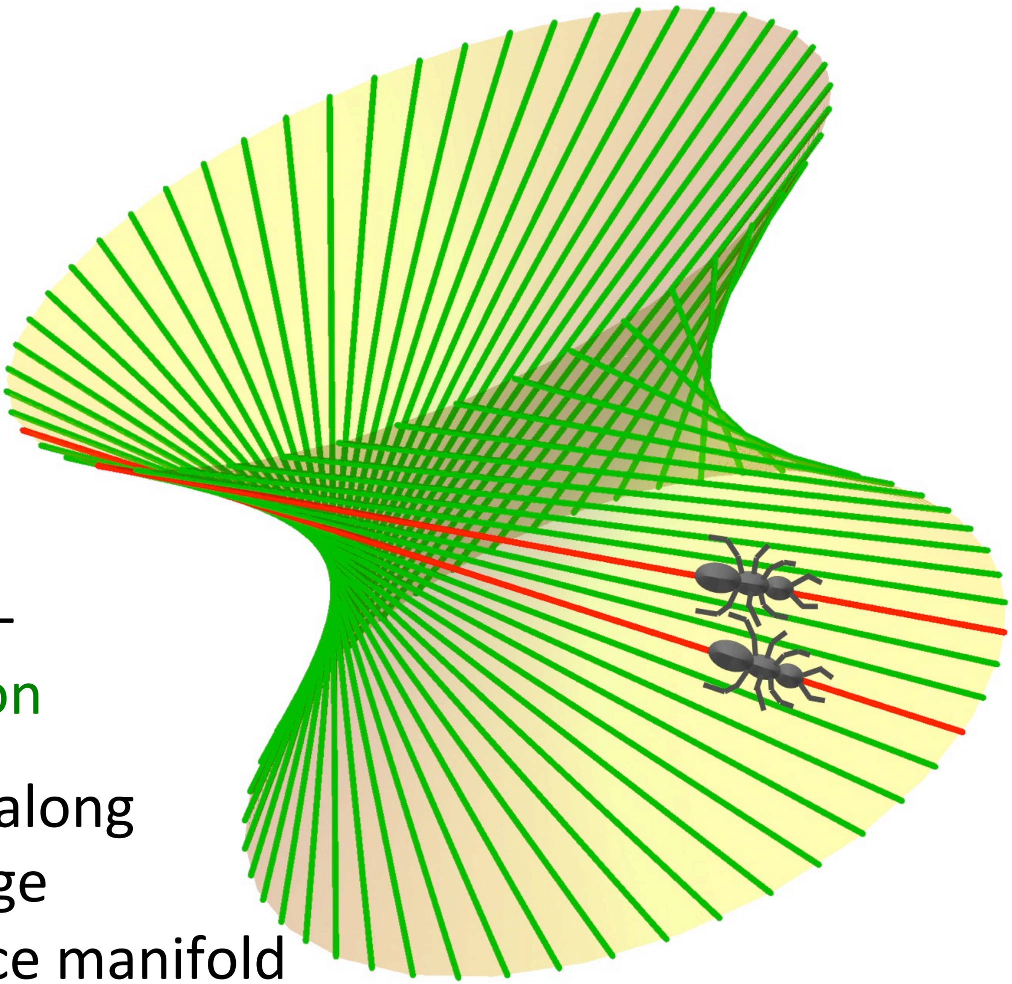


- **BUT** it is possible that the `heavy' field `climbs up' its potential, **destabilizing inflation**

Inflation and heavy fields

- one light field drives inflation
- other fields are heavy and completely decouple from the low-energy EFT governing inflation
- even if displaced from its minimum, the heavy field rolls back performing damped oscillations and does not affect inflation
- `natural motion' of the fields along geodesic lines, which may diverge on negative-curvature field-space manifold



Super-Hubble evolution

$$\dot{\zeta}/H = 2\eta_\perp \delta s \qquad \ddot{\delta s} + 3H\dot{\delta s} + m^2_{s(\mathrm{eff})}\delta s = 0$$

$$\frac{m^2_{s(\mathrm{eff})}}{H^2} = \frac{V_{;ss}}{H^2} + 3\eta_\perp^2 + \epsilon R_{\mathrm{fs}} M_{\mathrm{P}}^2$$

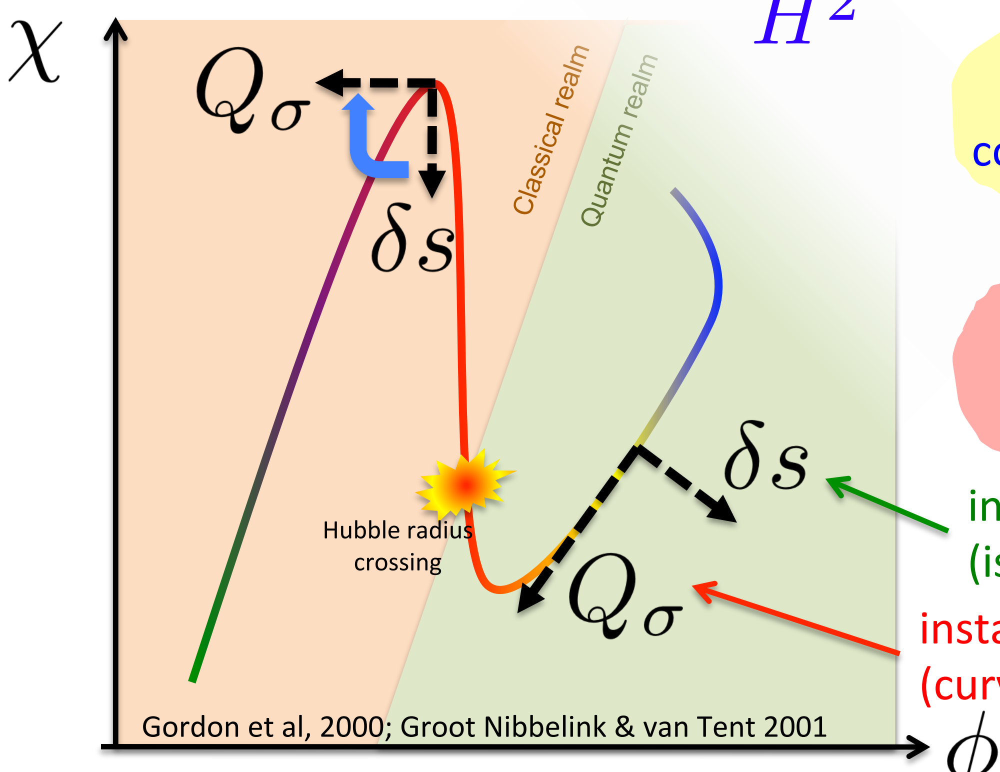
Hessian contribution

bending contribution

`geometrical’ cotribution

Renaux-Petel & KT ‘16
see also:
Gong & Tanaka ‘11

If large and negative – it can make entropy perturbation tachyonic, destabilizing inflation.



instantaneous entropy (isocurvature) perturbation $\quad \mathcal{S} \equiv \frac{1}{\sqrt{2\epsilon}}\delta s$

instantaneous adiabatic (curvature) perturbation $\quad \zeta \equiv \frac{1}{\sqrt{2\epsilon}} Q_\sigma$

$$\epsilon \equiv -\frac{\dot{H}}{H^2}$$

Geometrical destabilization

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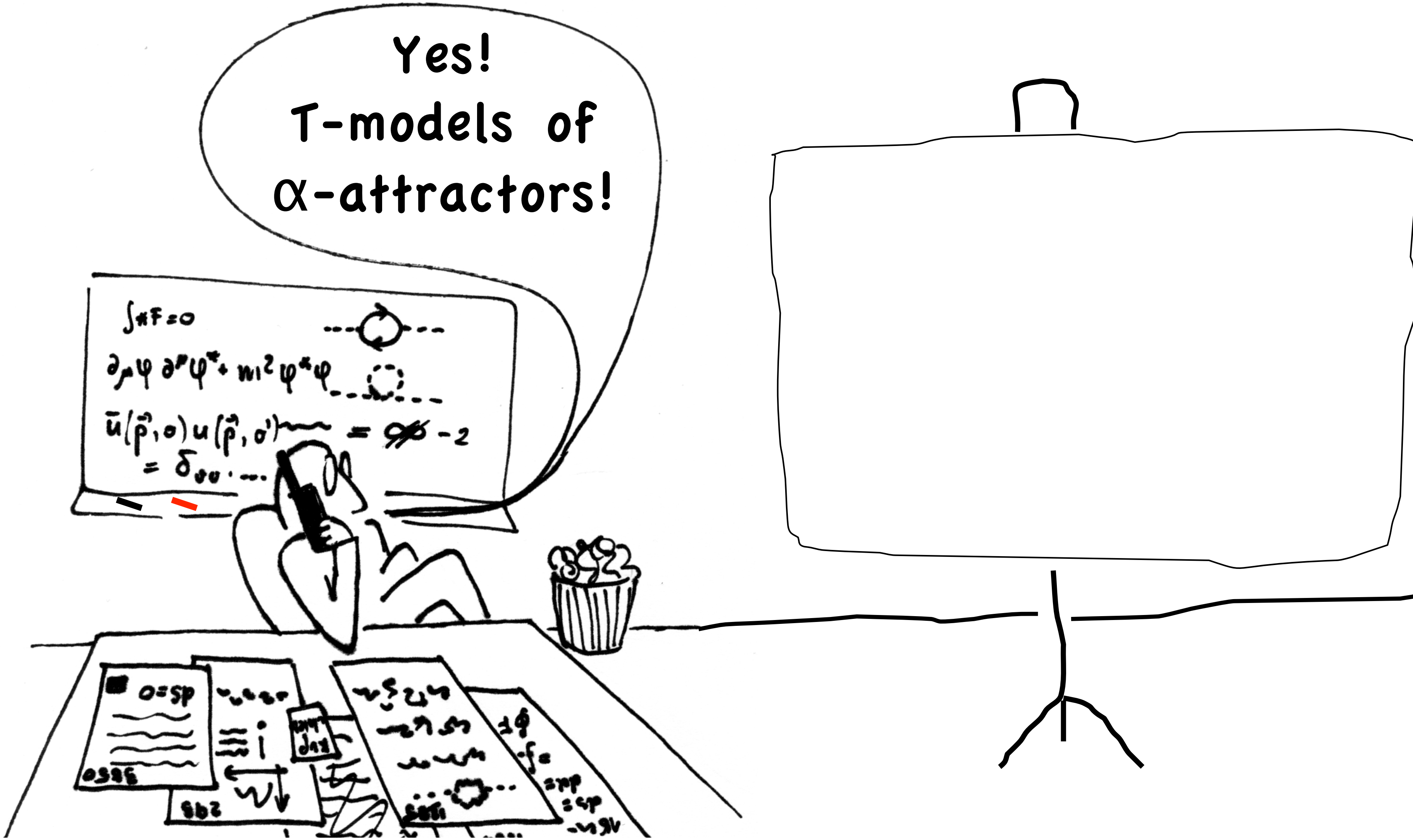
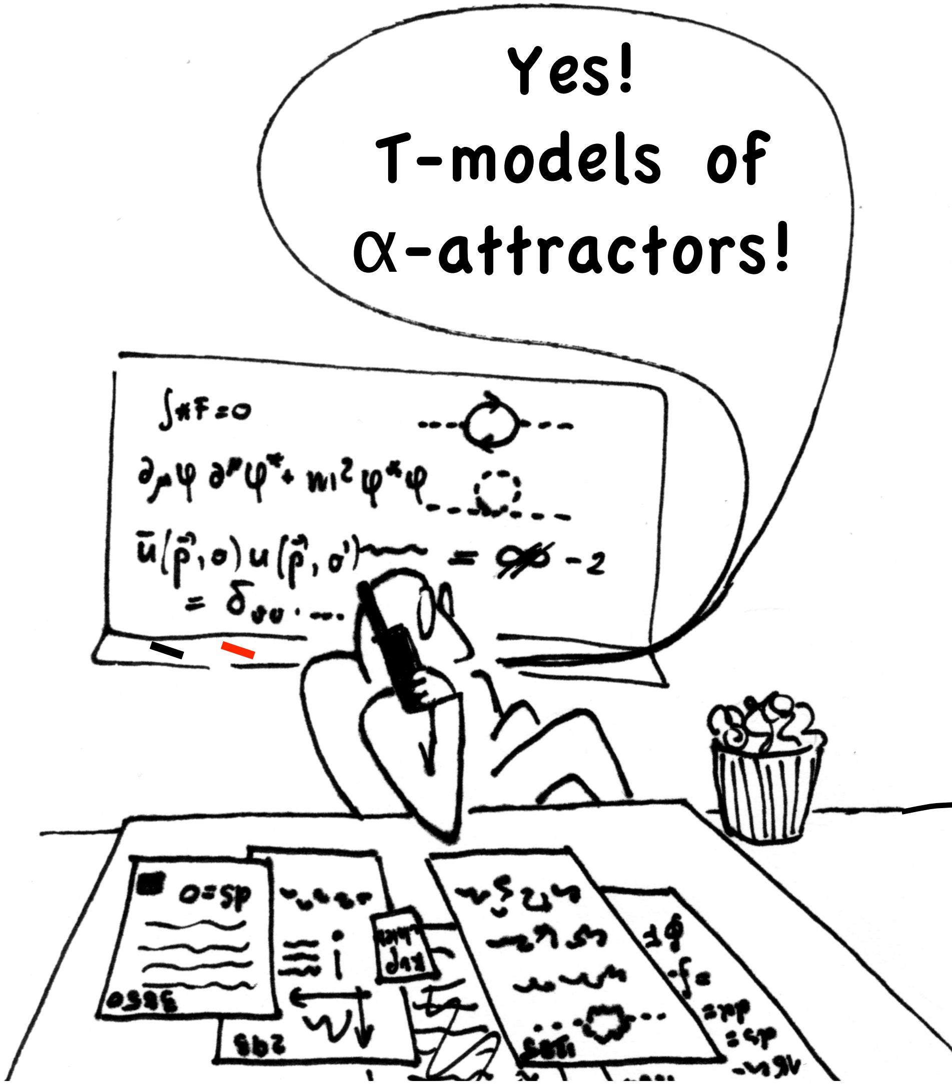
Are there **ANY** theoretically motivated models in which THAT contribution is large and negative?

Geometrical destabilization



Geometrical destabilization



- Superpotential

$$W_H = \sqrt{\alpha}\mu S\left(\frac{T-1}{T+1}\right)^n$$

- Kähler potential

$$K_H = -\frac{3\alpha}{2}\log\left(\frac{(T-\bar{T})^2}{4T\bar{T}}\right) + S\bar{S}$$

$$\left|\frac{T-1}{T+1}\right|^2 = \left(\frac{\cosh(\beta\phi)\cosh(\beta\chi)-1}{\cosh(\beta\phi)\cosh(\beta\chi)+1}\right), \qquad \beta = \sqrt{\frac{2}{3\alpha}}$$

- The potential and Lagrangian for T-models:

$$V(\phi,\chi) = M^4\left(\frac{\cosh(\beta\phi)\cosh(\beta\chi)-1}{\cosh(\beta\phi)\cosh(\beta\chi)+1}\right)^n\left(\cosh(\beta\chi)\right)^{2/\beta^2}$$

$$\mathcal{L} = \frac{1}{2}\left(\partial_\mu\chi\partial^\mu\chi + \cosh^2(\beta\chi)\partial_\mu\phi\partial^\mu\phi\right) - V(\phi,\chi)$$

Admits $\chi = 0$ inflating solution.

α-attractors

- Superpotential

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Geometrical destabilization in α-attractors

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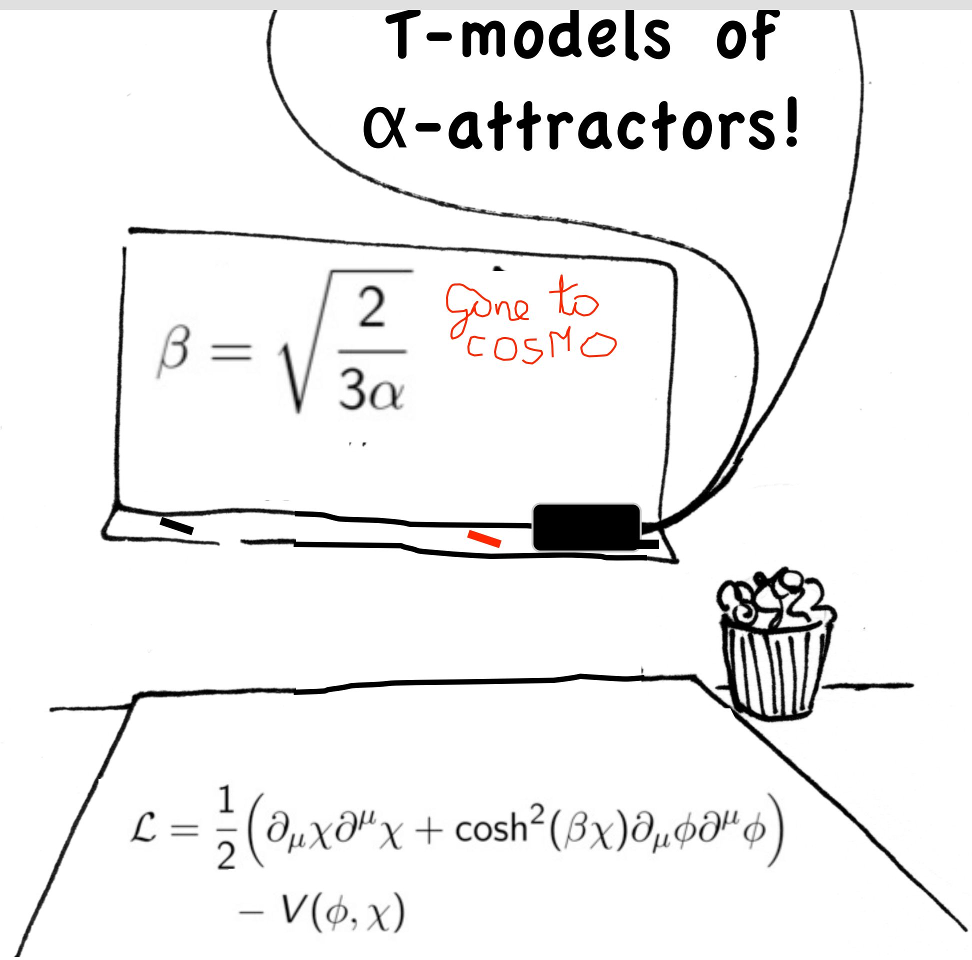


$$\frac{m^2_{s(\mathrm{eff})}}{H^2} = \frac{V_{;ss}}{H^2} + \epsilon R_{\mathrm{fs}} M_{\mathrm{P}}^2$$

Hessian contribution

`geometrical' cotribution

$$R_{\mathrm{fs}} = -\frac{2}{3\alpha} M_{\mathrm{P}}^{-2}$$

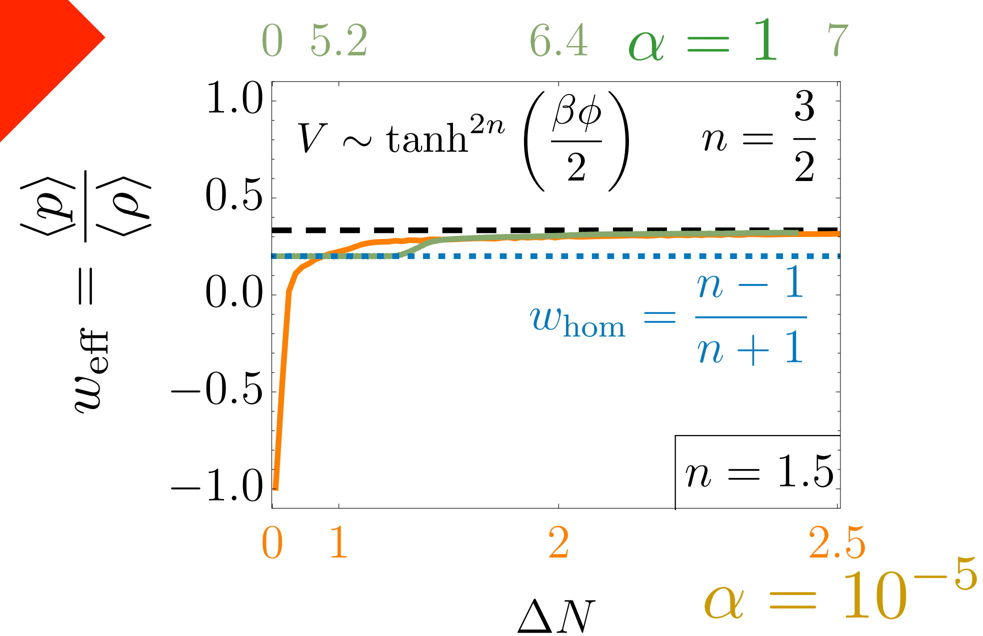
large negative for $\alpha \ll 1$

but during inflation $\epsilon = \alpha$

so effective mass becomes **large and negative** at the end of inflation, for $\epsilon \sim 1$

Geometrical destabilization in α-attractors

Self-resonance of the inflaton



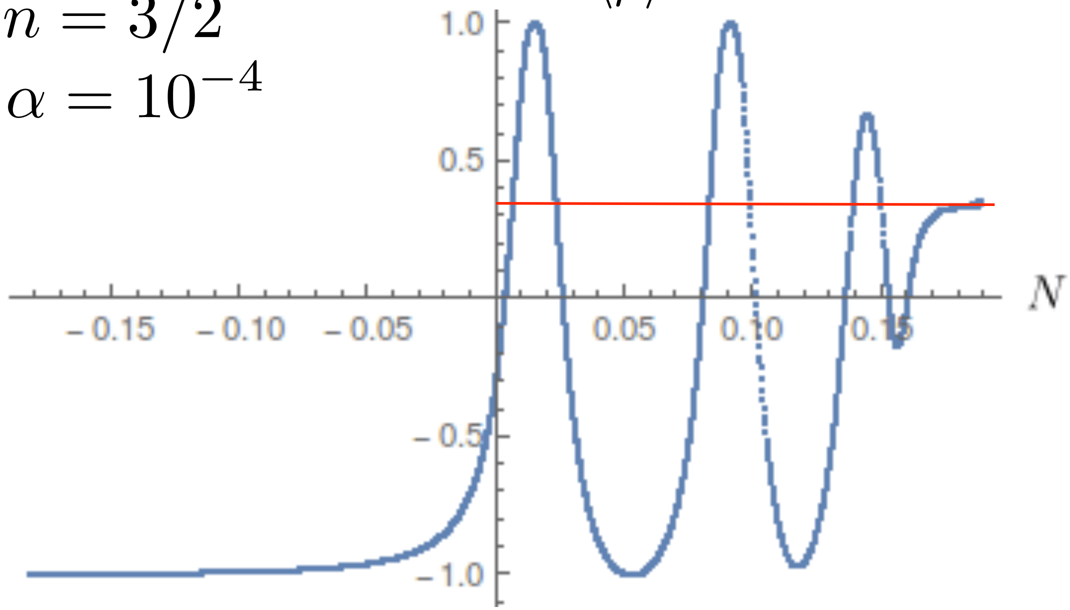
Amin & Lozanov 2016, 2017

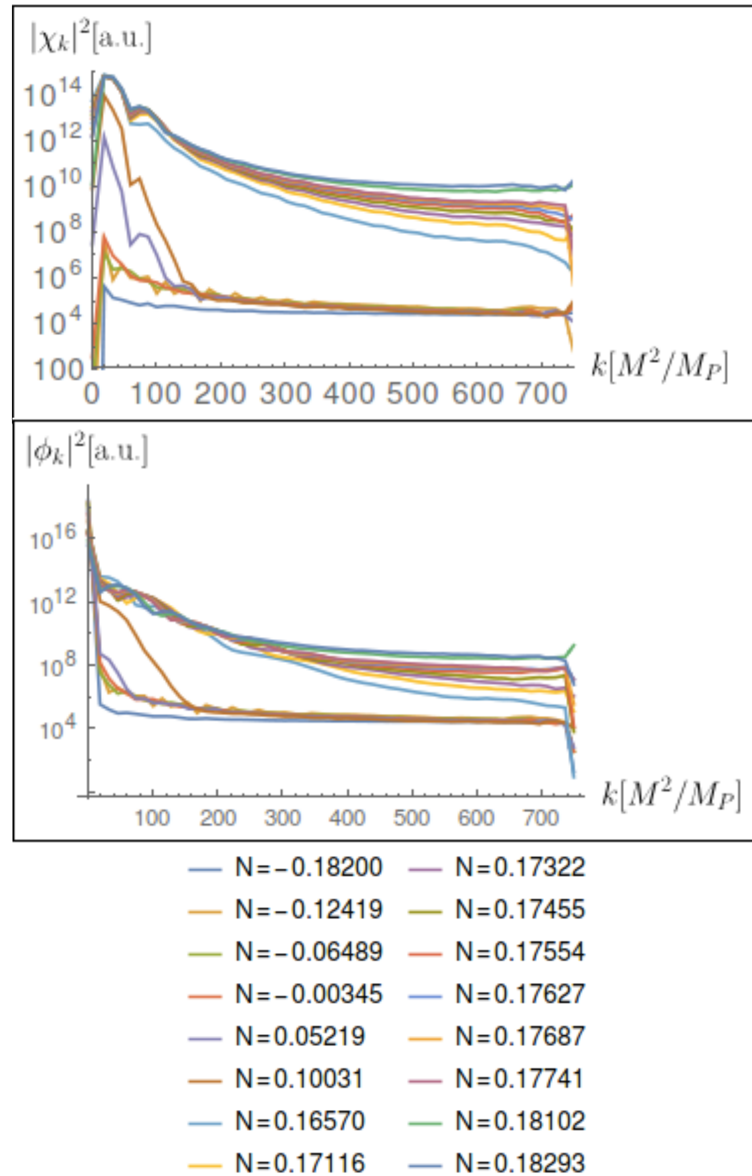
Numerical lattice simulations necessary

Geometrical destabilization in α-attractors

$$k_{\max} = 750 M^2/M_\mathrm{P}$$
$$N = 64$$
$$n = 3/2$$
$$\alpha = 10^{-4}$$

$$w_\mathrm{eff} = \frac{\langle p \rangle}{\langle \rho \rangle}$$





EOS of radiation after 1/6 efold

Geometrical destabilization in α-attractors

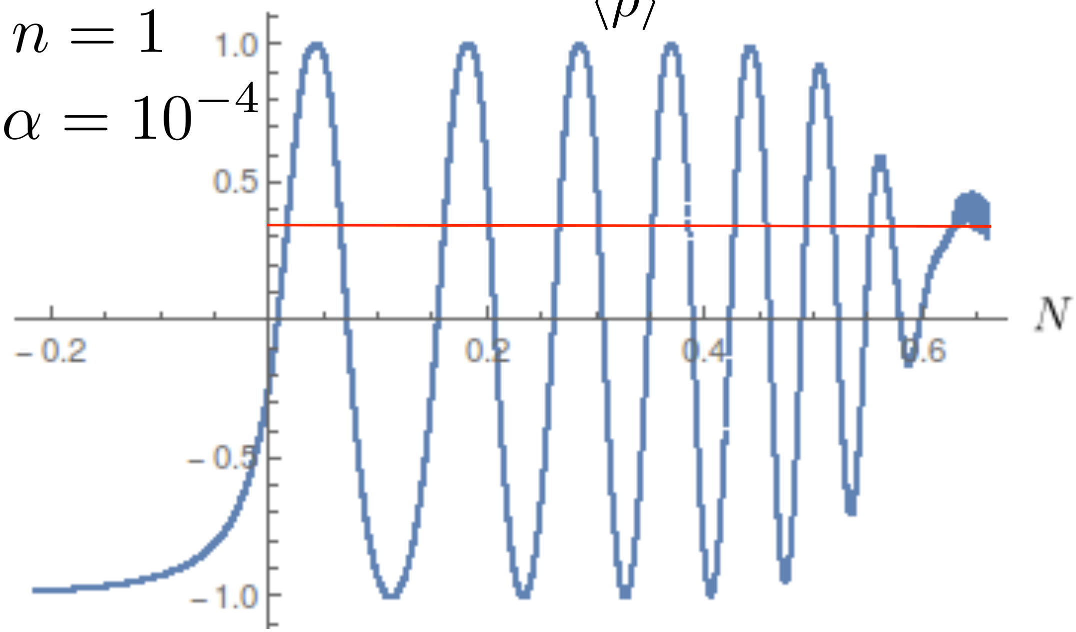
$k_{\max} = 250 M^2/M_{\rm P}$

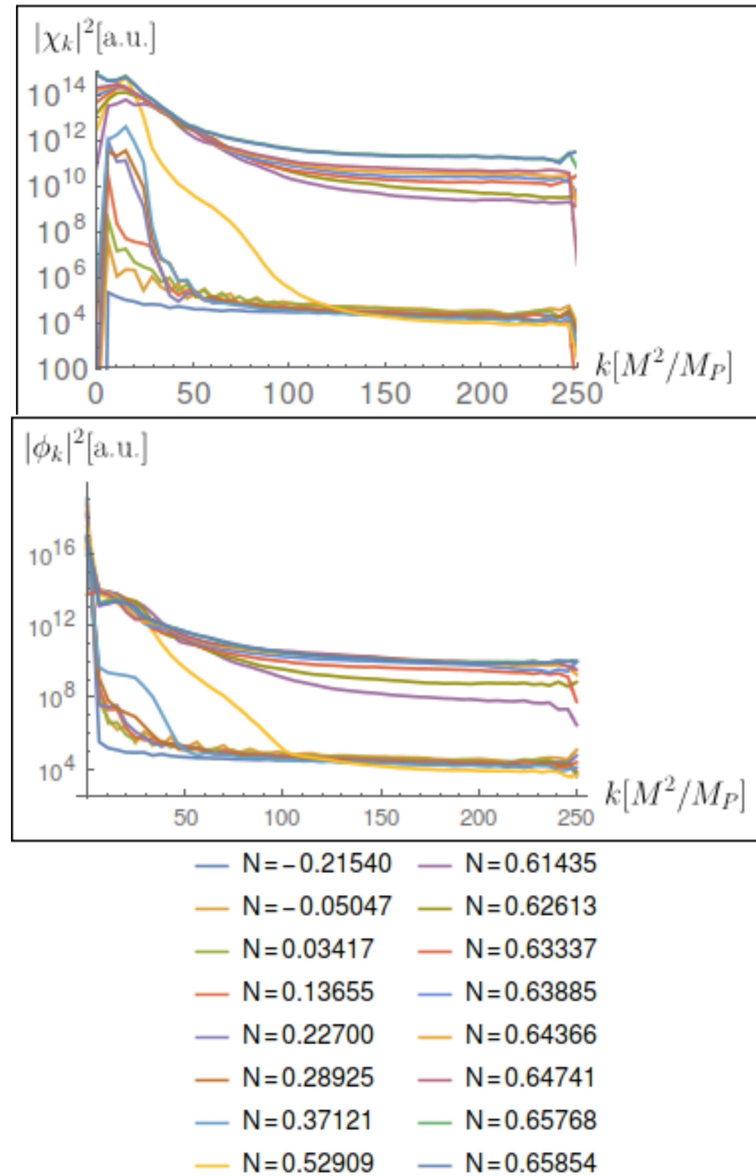
$N = 64$

$n = 1$

$\alpha = 10^{-4}$

$w_{\rm eff} = \dfrac{\langle p \rangle}{\langle \rho \rangle}$





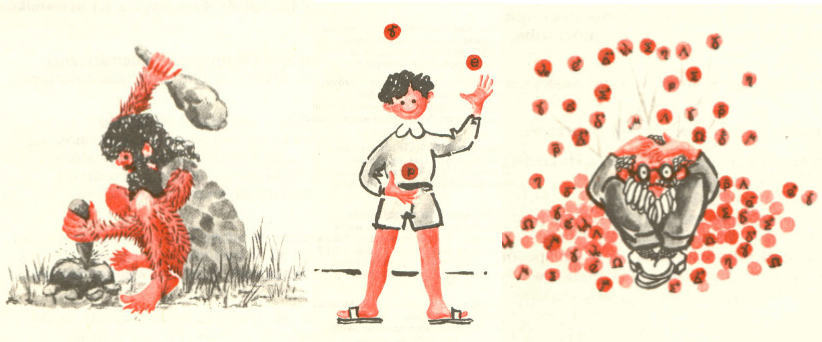
Hints:
EOS of radiation after <1 efold

Reheating in α-attractor T-models with $\alpha \lesssim 10^{-3}$

inflaton only Amin & Lozanov 2016, 2017	inflaton+spectator this work
self-resonance of inflaton $n \neq 1$: reheating $w_{\rm eff} = 1/3$ in a few efolds $n = 1$: oscillons form $w_{\rm eff} = 0$	geometrical destabilization of spectator spectator perturbation drive inflaton perturbations reheating $w_{\rm eff} = 1/3$ in a fraction of efold

Conclusions

- **geometrical destabilization of a scalar field** may be responsible for reheating: mode instability and the breakup of the inflaton condensate
- **improvement** of inflatonary predictions: less uncertainty about the duration of the reheating, as EOS-RD achieved immediately



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