Lightish but clumpy: scalar dark matter from inflationary fluctuations

Gonzalo Alonso-Álvarez

Based on: Gonzalo Alonso-Álvarez, J. Jaeckel, **arXiv:1807.09785**

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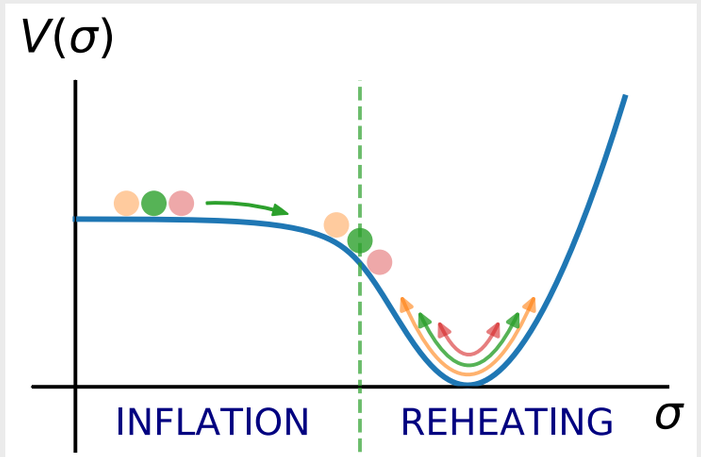
neutrinos, dark matter & dark energy physics

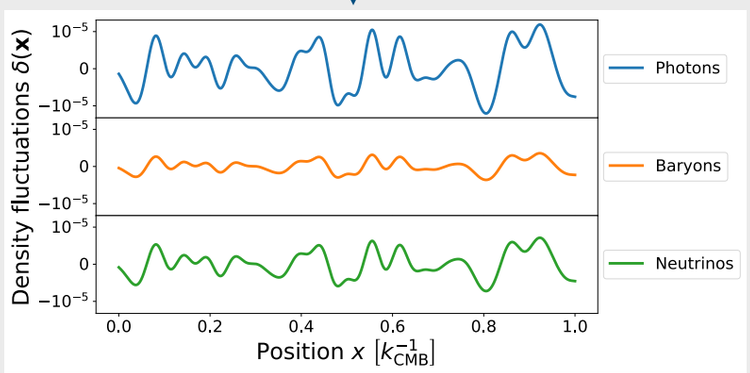
Horizon 2020

UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

(Dark) matter & inflation

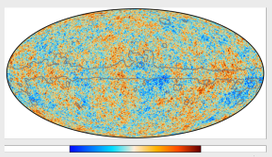
Ordinary matter





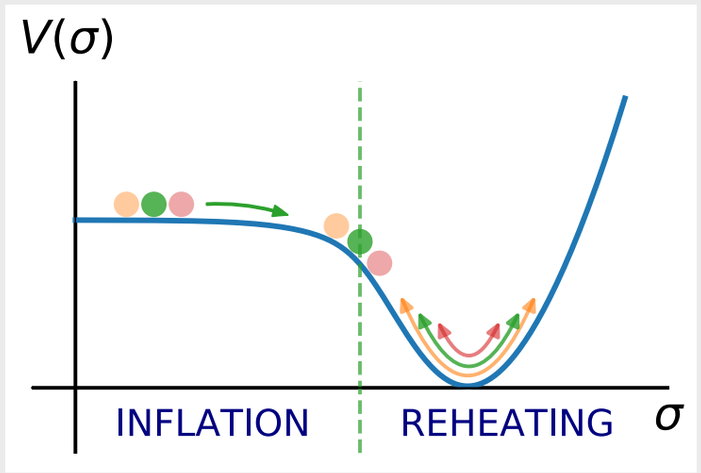
Adiabatic perturbations

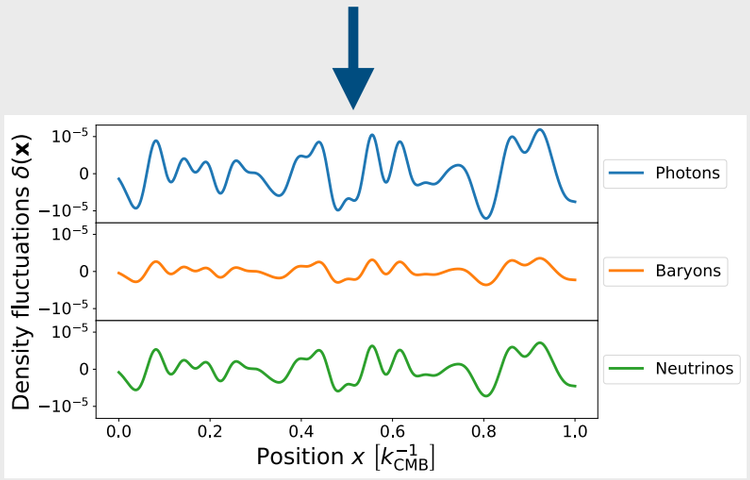
seen in the CMB



(Dark) matter & inflation

Dark matter?





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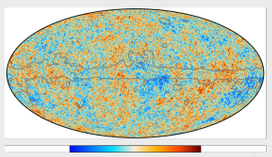
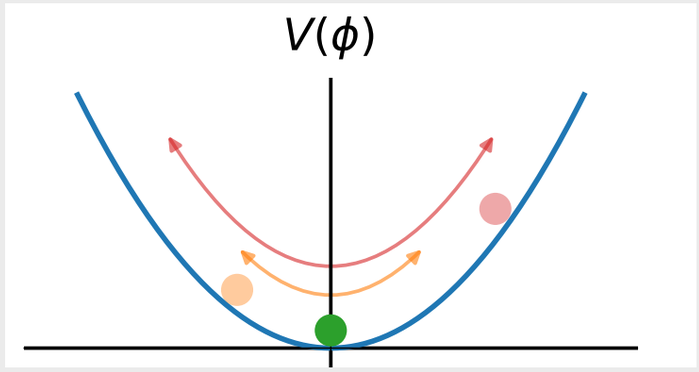
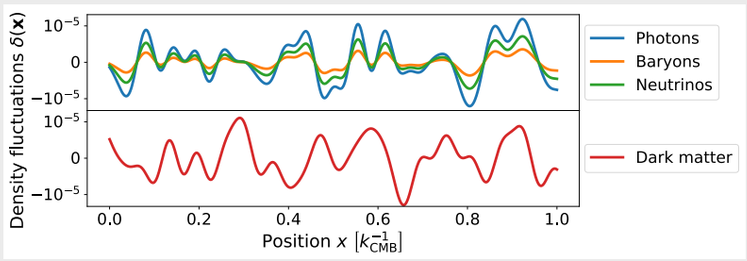




Light

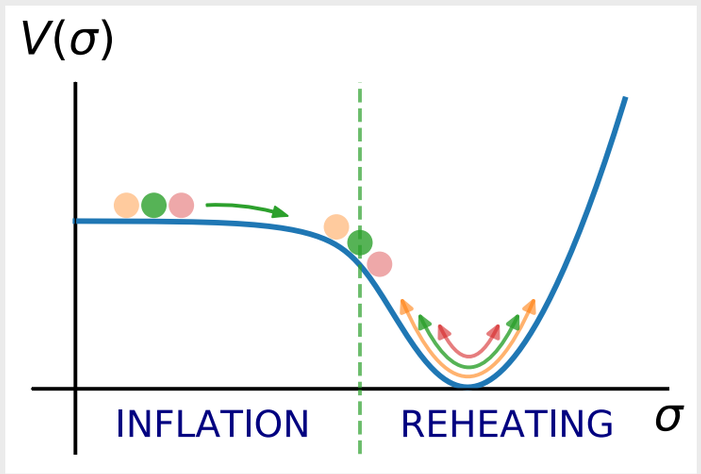


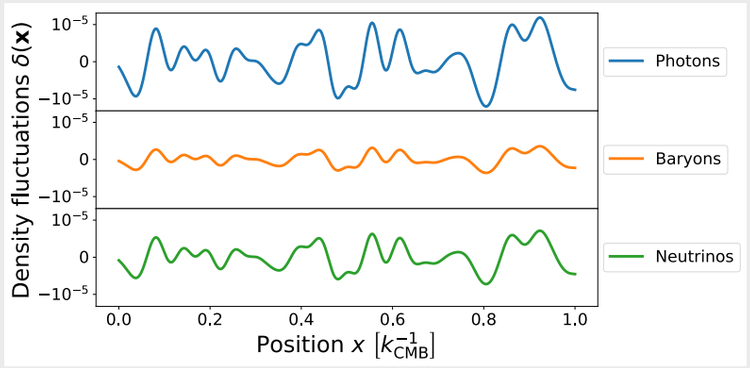
Isocurvature perturbations

$$\Rightarrow \quad \frac{\delta\rho_{\rm iso}(k_\star)}{\delta\rho_{\rm ad}(k_\star)} \lesssim 0.03$$

at scales $k_{\rm CMB}^{-1} \simeq 20\ {\rm Mpc}$

(Dark) matter & inflation





Adiabatic perturbations

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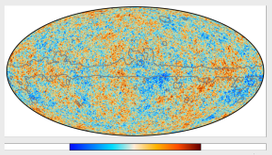

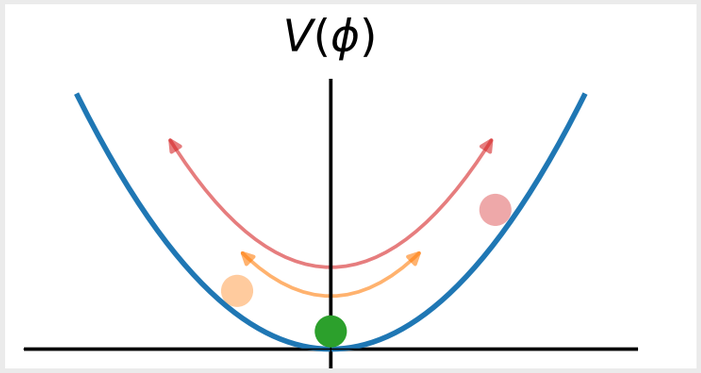

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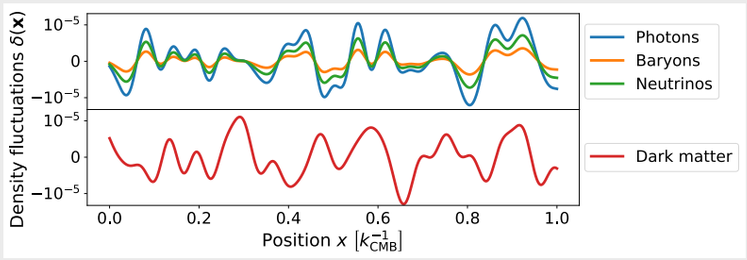

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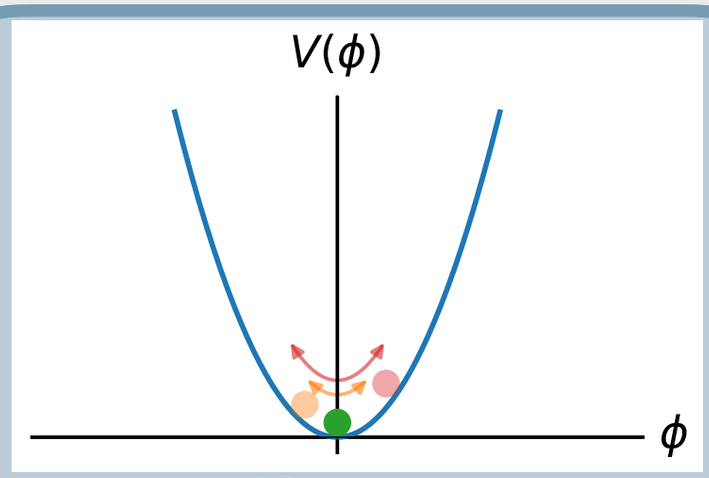
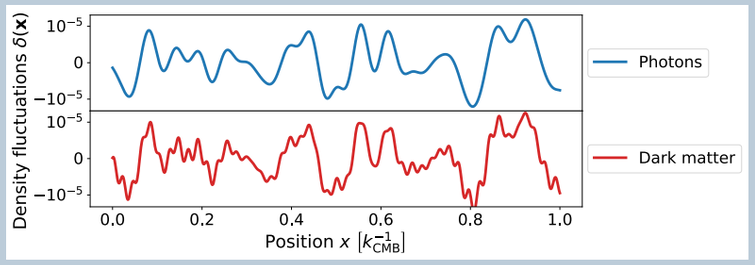
at scales $k_{\rm CMB}^{-1} \simeq 20$ Mpc

Dark matter!



Heavy



Isocurvature perturbations suppressed at large scales.

But only if $m \sim \mathcal{O}(H_I)$!

How may this happen?

Non-minimal coupling to gravity

Action in the Jordan frame:

$$S = \int \mathrm{d}^4x\sqrt{-g}\left(\left(\tilde{M}_p^2 - \xi\phi^2\right)R - \frac{1}{2}g^{\mu\nu}\nabla_\mu\phi\nabla_\nu\phi - m^2\phi^2\right)$$

Effective mass for ϕ :

$$m_{\mathrm{eff}}^2 = m^2 + \xi R\,, \qquad R \propto H^2$$

Bare mass (constant)

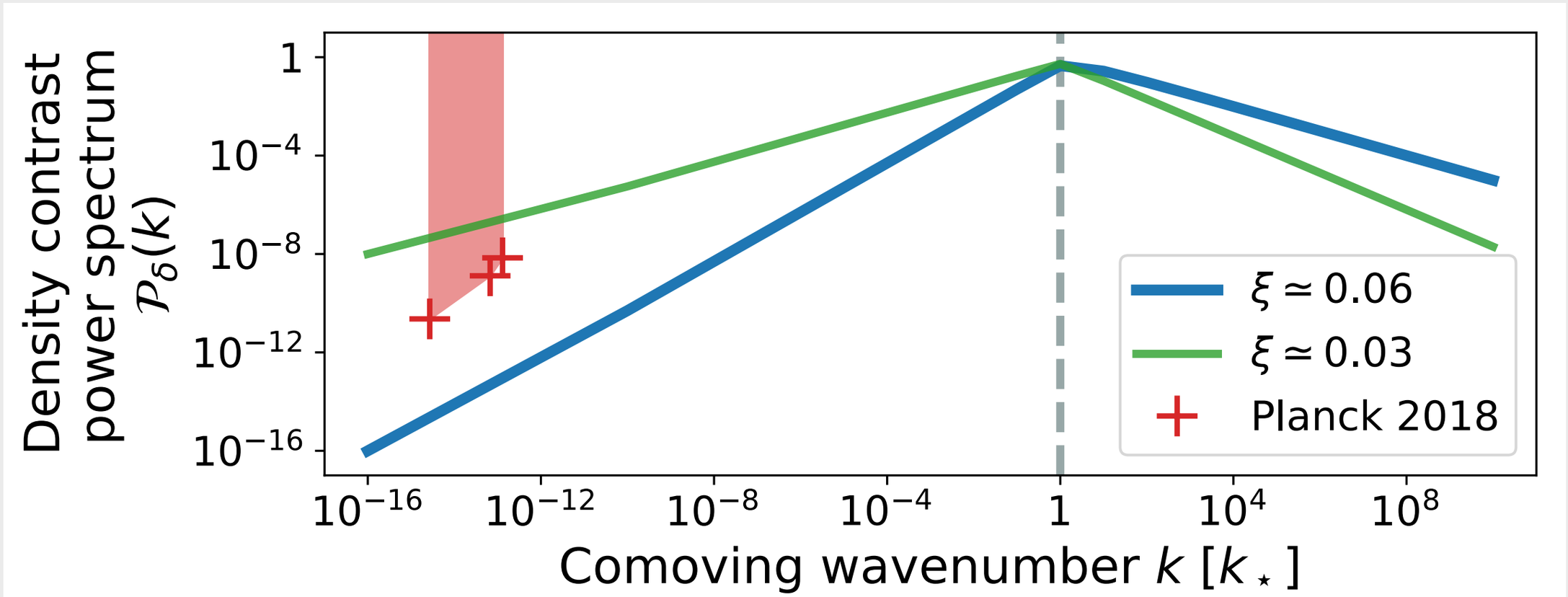
Gravitational mass (space-time dependent)

The field is heavy during inflation, but it can be light from then on.

Power spectrum & isocurvature

The density power spectrum is peaked at the intermediate scale $k_\star^{-1}$.

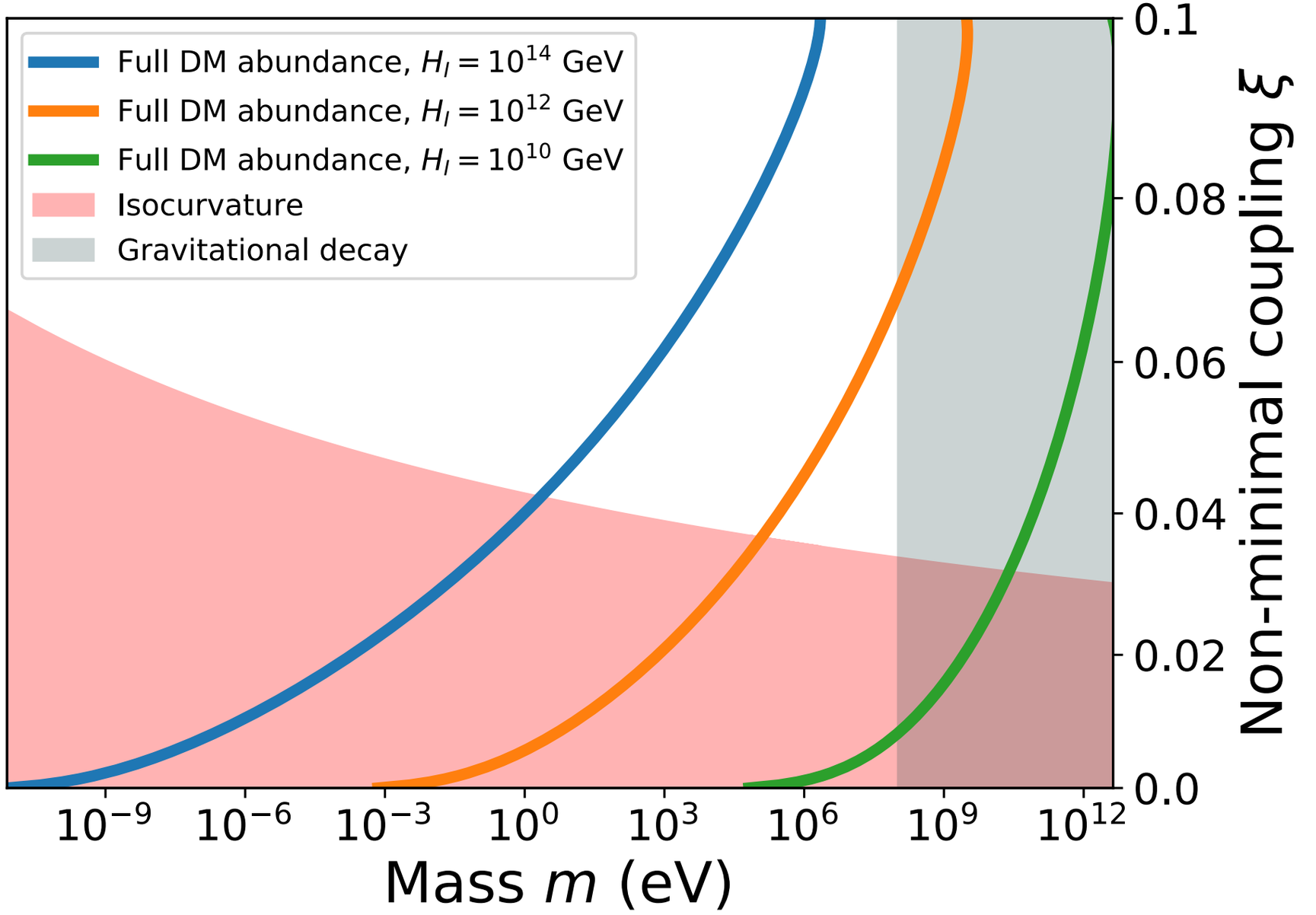
$$k_\star^{-1} \simeq \underset{(1\,\mu\mathrm{pc})}{4 \cdot 10^7\,\mathrm{km}} \sqrt{\frac{\mathrm{eV}}{m}}$$



Isocurvature fluctuations are small enough at the CMB scales.

Parameter space

For a given m and ξ, fixing the abundance to the dark matter one selects a scale of inflation.



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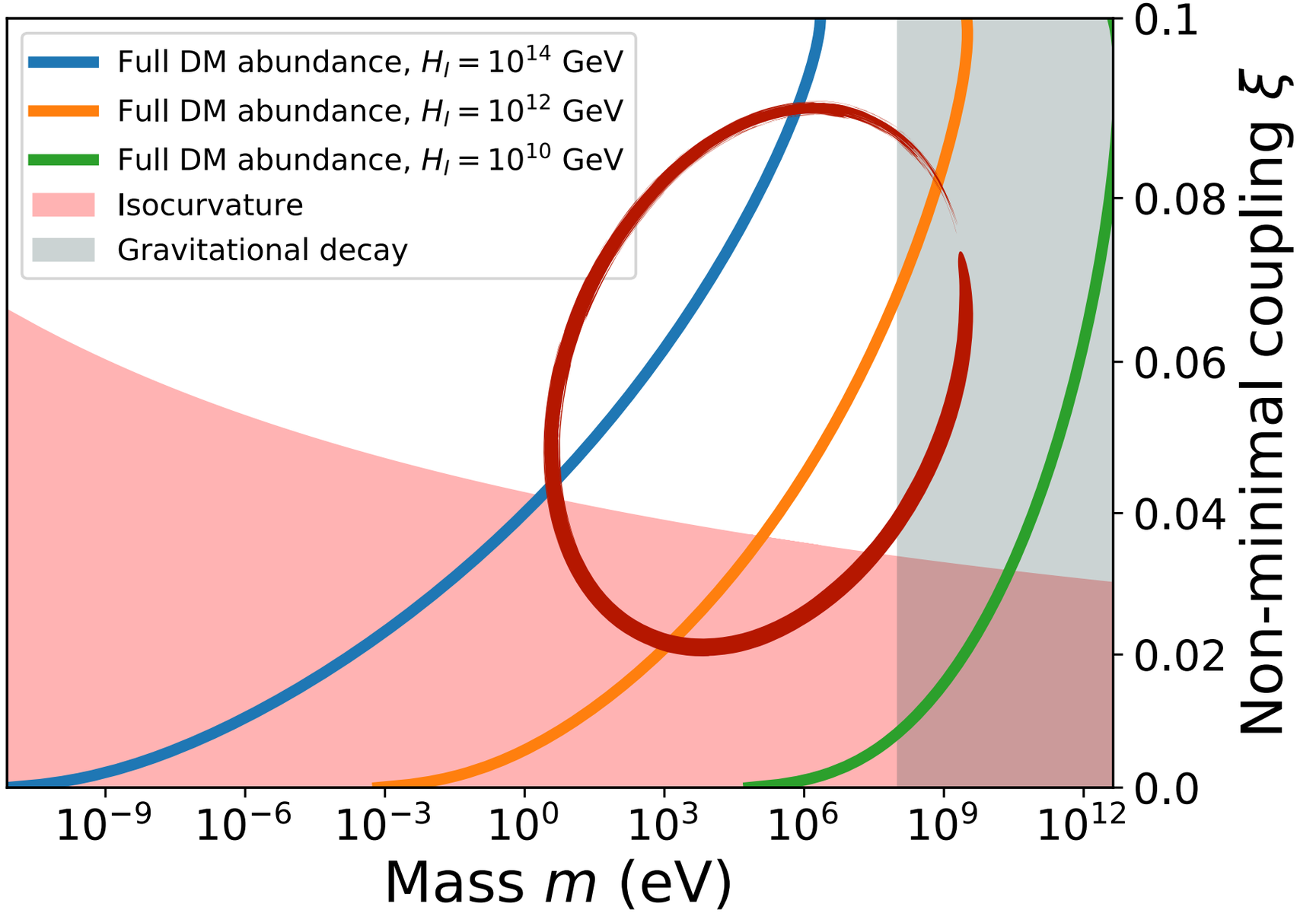

In one sentence

1. Dark matter can be generated from quantum fluctuations of a non-minimally coupled light scalar field during inflation.

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Thanks!

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