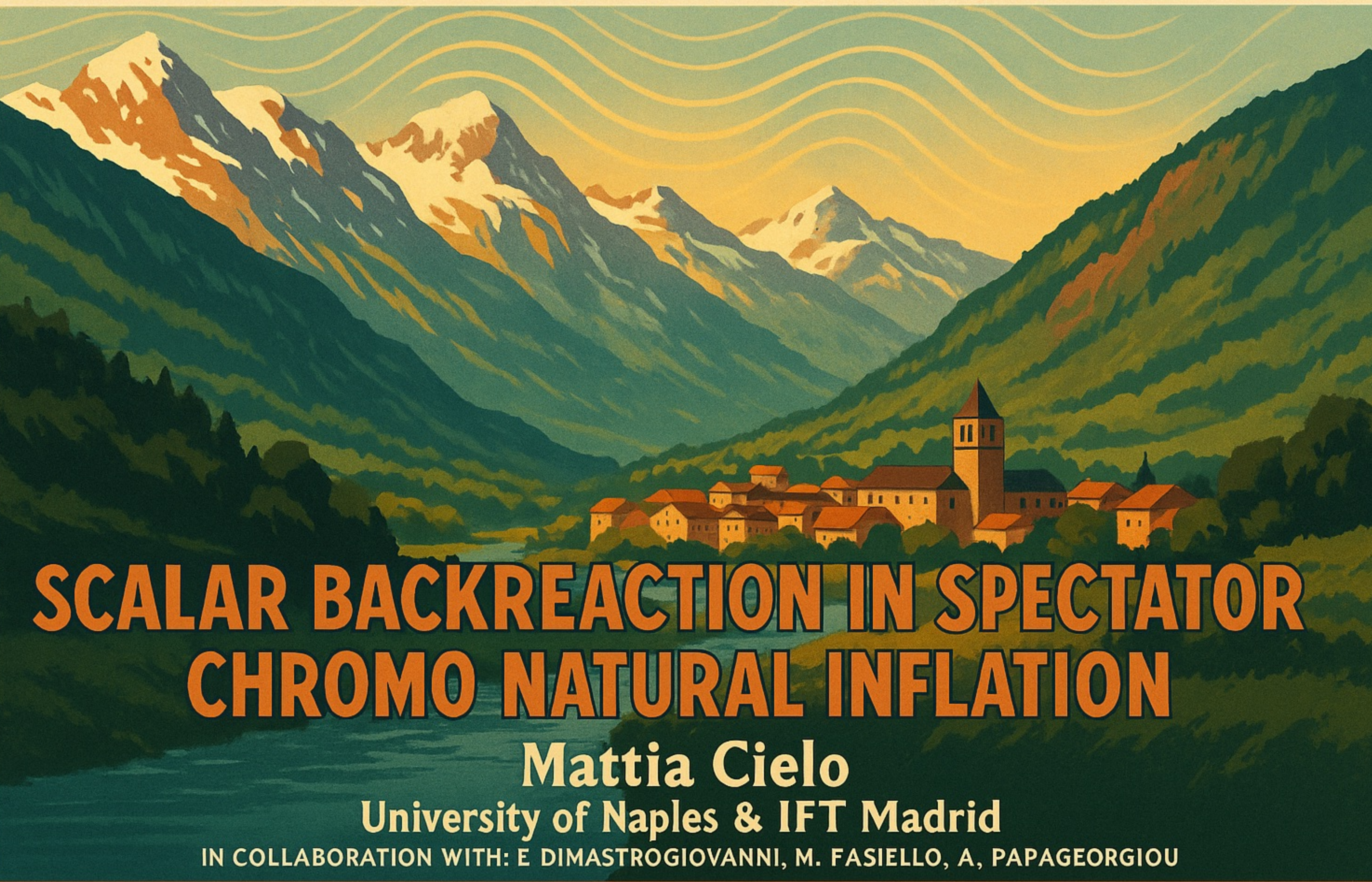

SCALAR BACKREACTION IN SPECTATOR CHROMO NATURAL INFLATION

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THE DAWN OF GRAVITATIONAL WAVE COSMOLOGY – BENASQUE

TO APPEAR SOON ON ARXIV

ALP and Gauge Fields

WHY AXIONS?

- Theoretically welcomed in many extensions of the Standard Model
- They naturally couple to gauge fields

WHY AXIONS DURING INFLATION?

- Preventing loop corrections to the inflaton mass (shift symmetry)
- Natural way to realize the Slow-Roll (in the minimal CNI model)
- Supporting rich phenomenology (chiral GW, Non-Gaussianities, PBH ...)

Freese et al. : PRL - 65 (1990) 3233 - 3236

The Spectator Chromo Natural Inflation

Inflaton

ALP

$$S_{SCNI} = \int d^4x \left[\frac{M_{Pl}^2}{2} R + \mathcal{L}_\phi - \frac{1}{2}(\partial \chi)^2 - U(\chi) + \right.$$
$$\left. - \frac{1}{4} F^a_{\mu\nu} F^{a\mu\nu} + \frac{\lambda \chi}{4f} F^a_{\mu\nu} \tilde{F}^{a\mu\nu} \right]$$

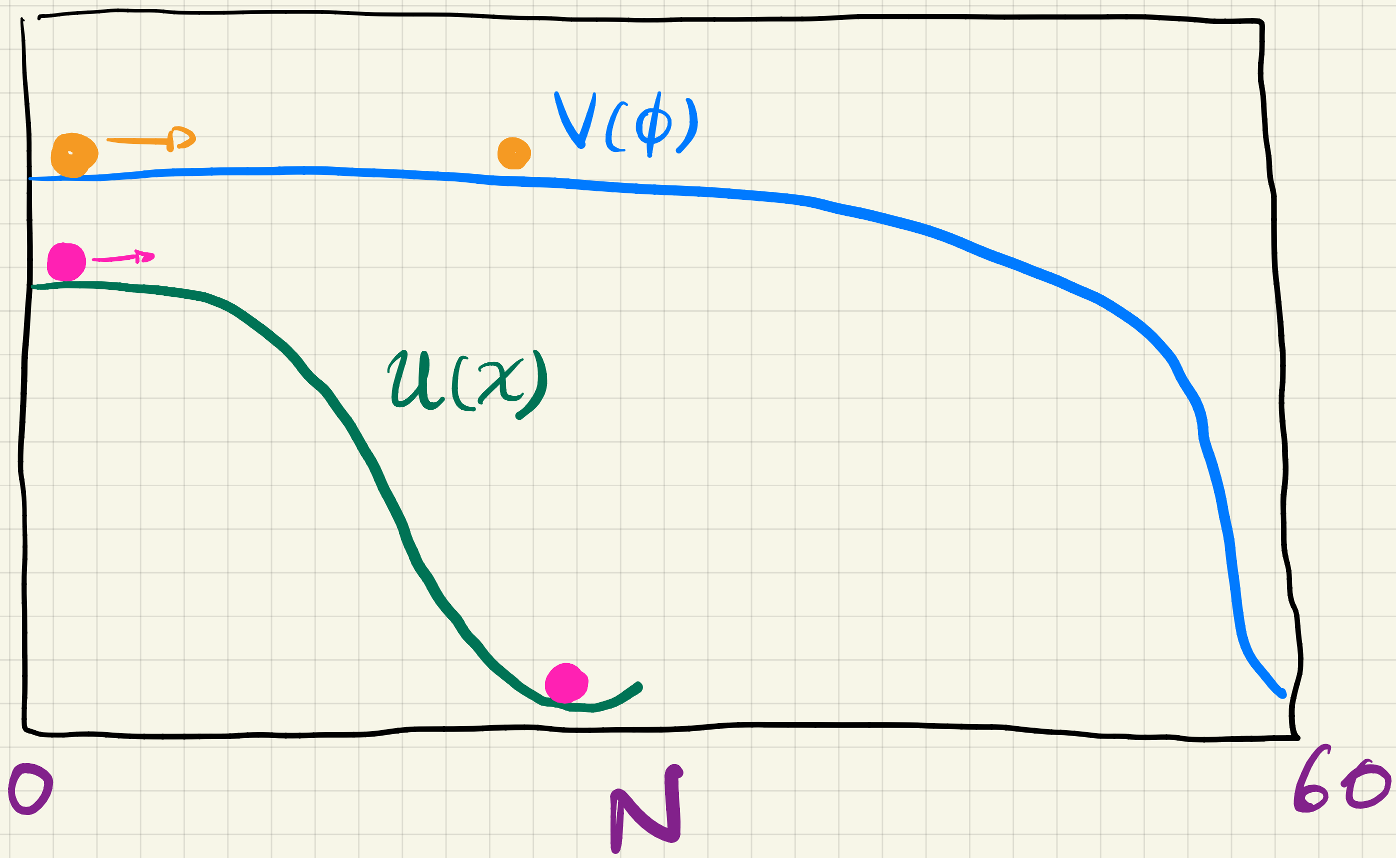
where :

$$\begin{cases} U(\chi) = \mu^4 \left[1 + \cos\left(\frac{\chi}{f}\right) \right] \\ \\ F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu - g \varepsilon^{abc} A^b_\mu A^c_\nu \end{cases}$$

The Model Parameters

(f, g, λ)

Our Set - up



- The Axion decays well before the end of Inflation
- It Triggers a tachyonic instability inside the horizon

The background Dynamics : NO Backreaction YET

The isotropic configuration : $A^a_0 = 0$, $A^a_i = \delta^a_i a(t) Q(t)$

ALP equation: $\ddot{\chi} + 3H\dot{\chi} + \partial_\chi u + 3g\frac{\lambda}{f}Q^2(\dot{Q} + HQ) = 0$

Q evolution : $\ddot{Q} + 3H\dot{Q} + (\dot{H} + 2H^2)Q + gQ^2\left(2gQ - \frac{\lambda\dot{\chi}}{f}\right) = 0$

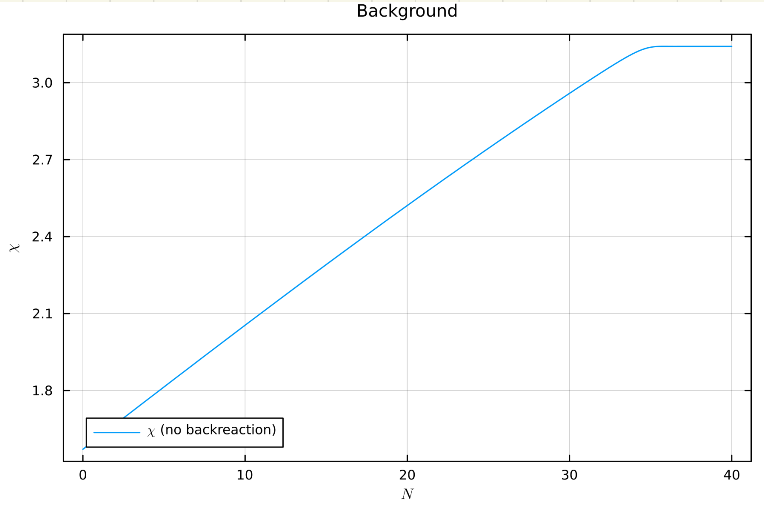
Relevant Functions

$$m_Q = g\frac{Q}{H} \qquad \xi = \frac{\lambda\dot{\chi}}{f\,2H} \qquad \Lambda = \frac{\lambda Q}{f}$$

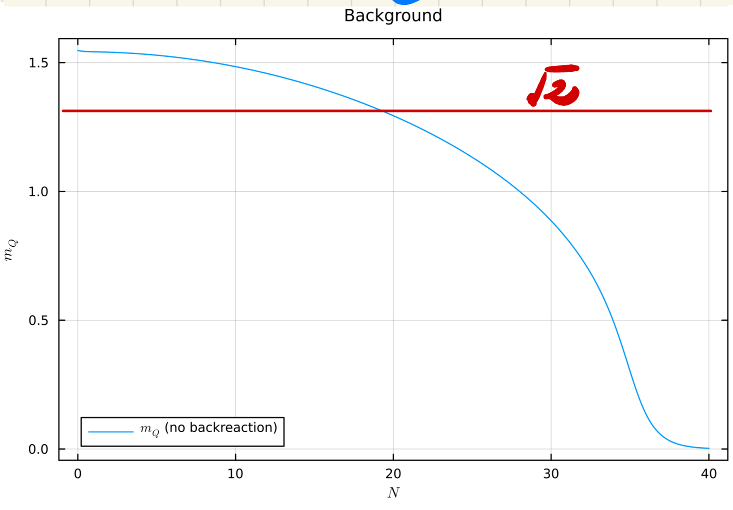
$$\xi \simeq \frac{1}{m_Q} + m_Q$$

Evolution of the Relevant Functions: NO BR YET

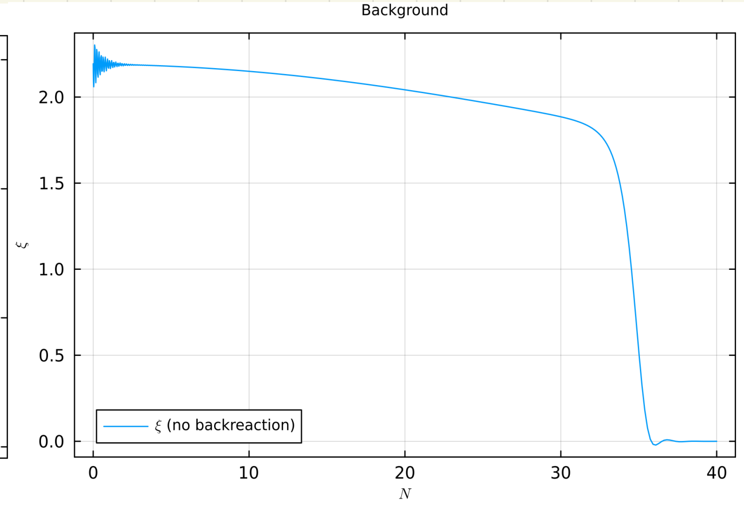
ALP



m_Q



ξ



Reaches the Minimum of the Potential and Stabilize

Typical "Bell" shape

The particle production function goes to zero rapidly

$m_Q < \sqrt{2} \Rightarrow$ tachyonic instability

for the scalar perturbations

The Perturbations

The Scalars

$$\Big(\underbrace{X\,,\ Z\,,\ \phi}_{\text{gauge sector Perturbations}}\,,\ \underbrace{\Phi}_{\text{Inflaton Perturbation}}\Big)$$

The Tensors

$$\Big(\underbrace{T_{R/L}}_{\text{gauge tensor modes}}\,,\ \underbrace{\psi_{R,L}}_{\text{Gravitational Waves}}\Big)$$

Impact of the Perturbations on the Background

$$\ddot{\chi} + 3H\dot{\chi} + \partial_{\chi} U + \frac{3g\lambda}{f} Q^2 (\dot{Q} + HQ) + \mathcal{B}_{\chi} = 0$$

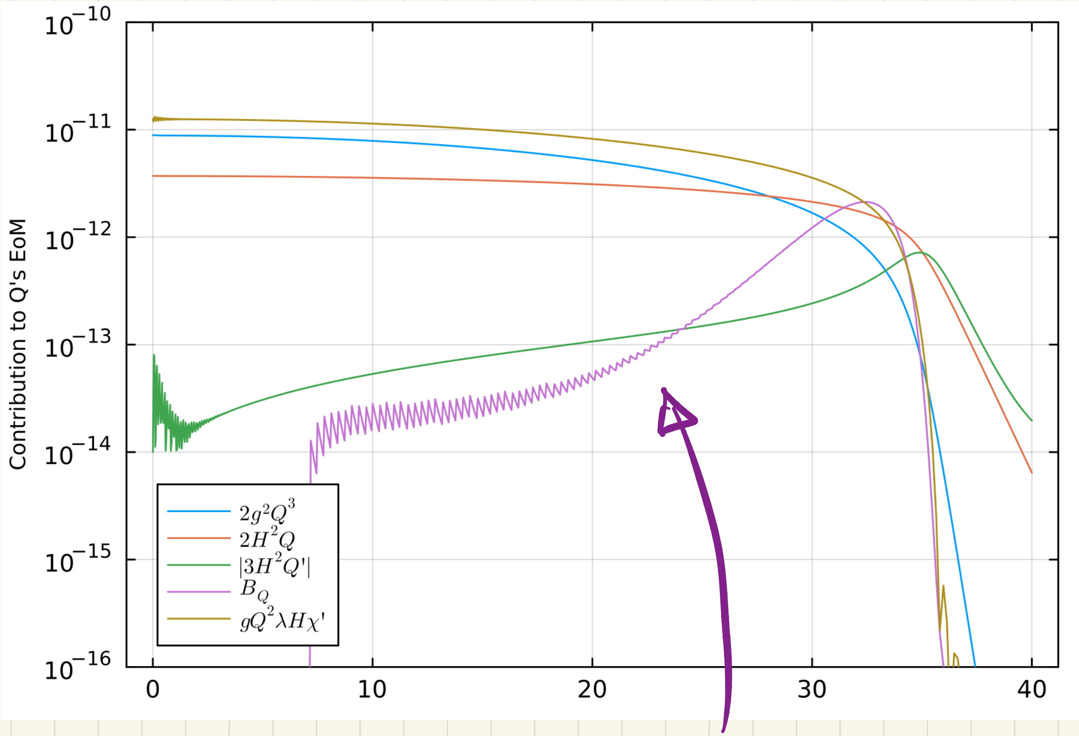
$$\ddot{Q} + 3H\dot{Q} + (\dot{H} + 2H^2) Q + g Q^2 \left(2gQ - \frac{\lambda \dot{\chi}}{f}\right) + \mathcal{B}_Q = 0$$

$$\mathcal{B}_{\chi} = \frac{V^{(3)}(\chi)}{2a^2} \int \frac{d^3k}{(2\pi)^3} \left|\hat{X}(\tau, k)\right|^2$$

$$\mathcal{B}_Q = \frac{2g\Lambda^3 m_Q}{3a^2} \int \frac{d^3k}{(2\pi)^3} \frac{k^2 (k^2 + a^2 H^2 m_Q^2)}{(k^2 + 2a^2 H^2 m_Q^2)^2} \left|\hat{X}(\tau, k)\right|^2$$

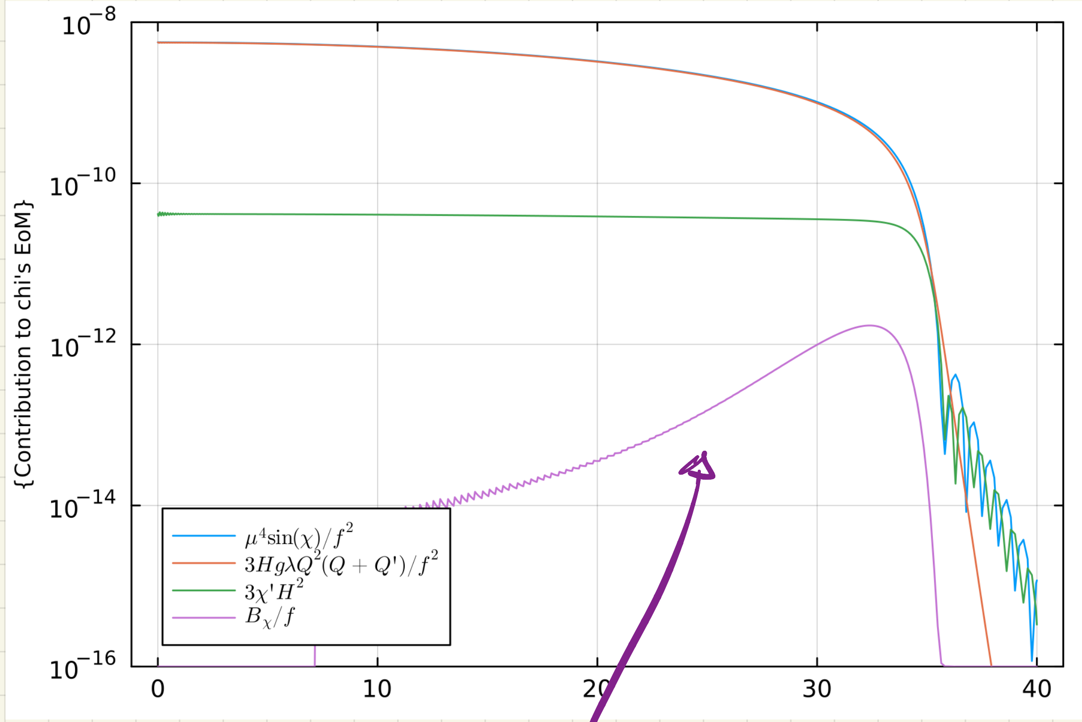
Preliminary evalutation of the scalar Backreaction

Q's EoM



B_Q

χ's EoM



B_χ

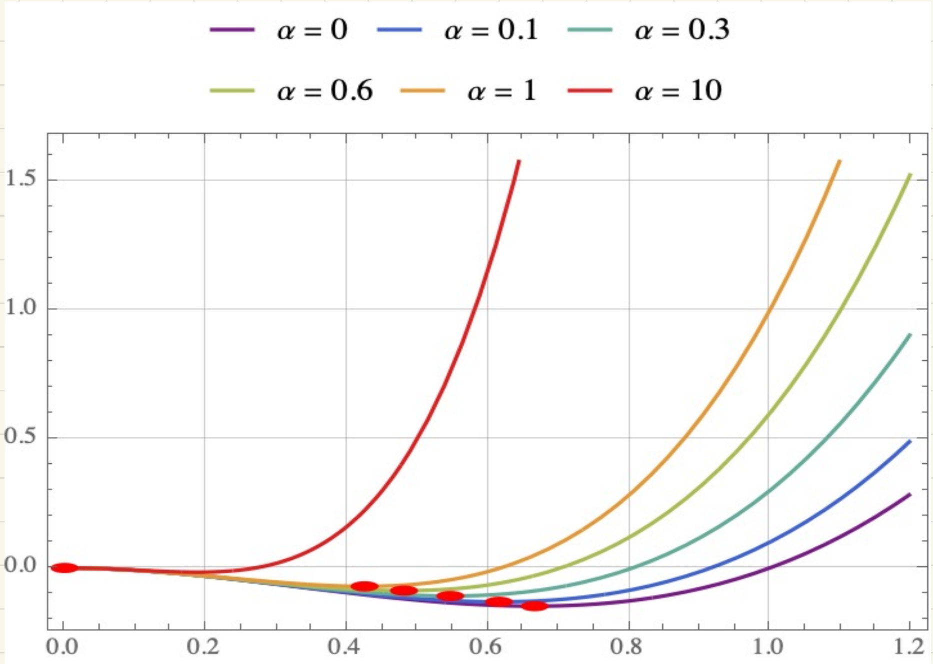
*) In this run we are not including the Backreaction

Let's train our intuition on Backreaction

$$Q \text{ equation} \simeq \dot{Q} + \frac{\partial V_{eff}}{\partial Q} = 0 \qquad B_Q \simeq Q^3 \cdot \underbrace{\int \text{- - - -}}_{\alpha(t)}$$

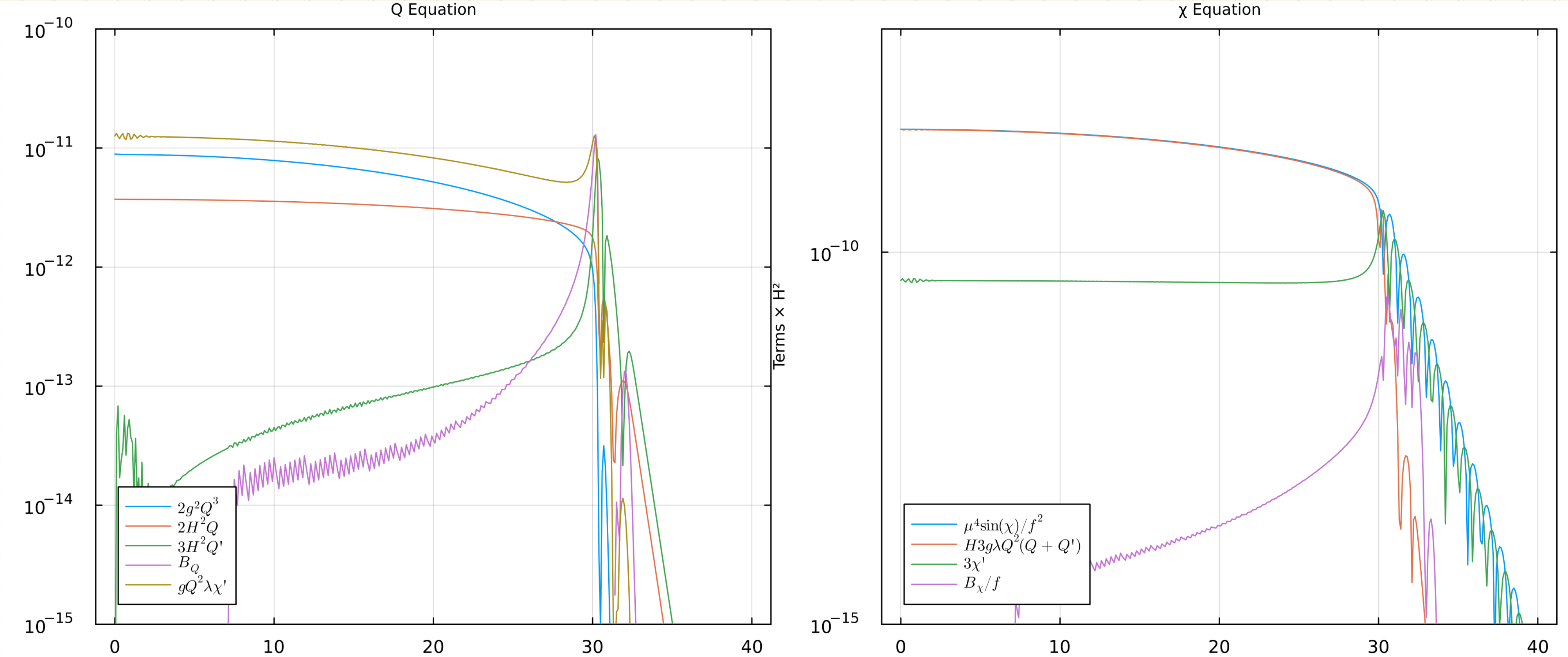
$$V_{eff} = \# Q^3 - \# Q^2 + \left(\#_{small} + \alpha(t) \right) Q^4$$

When this NEW effective potential dominates, it forces the field Q to the Minimum Q ->0



Let's switch the Backreaction ON!

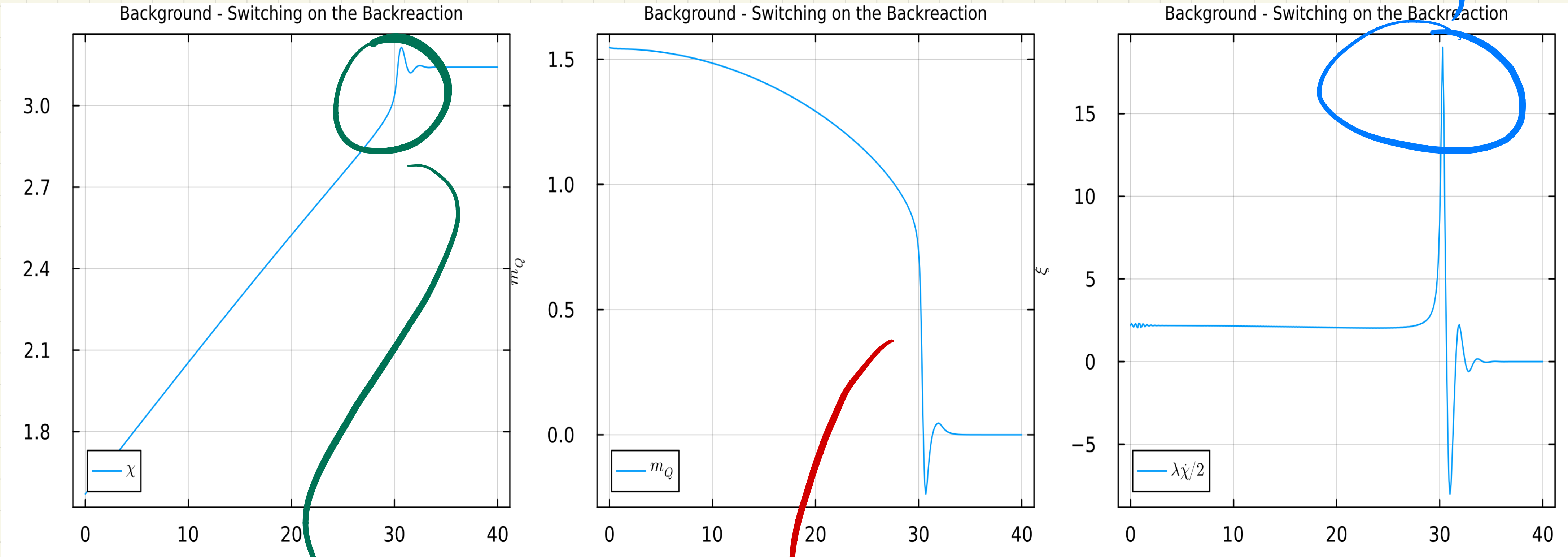
– The FIRST NUMERICAL IMPLEMENTATION –



julia

Let's switch the Backreaction ON!

Bump in ξ



χ rolls nearly frictionless

The friction term for χ goes to $\to 0$

Amplification of ξ

Where are the shadows of this mechanism ?

GFTM $\quad T''_{R,L} + \left\{ k^2 + \frac{2}{\eta^2} \left[m_Q \xi \pm k\eta \left(m_Q + \xi \right) \right] \right\} T_{R,L} \simeq f(\psi, \varepsilon)$

An amplification of the $T_{R,L}$ sources the GWs

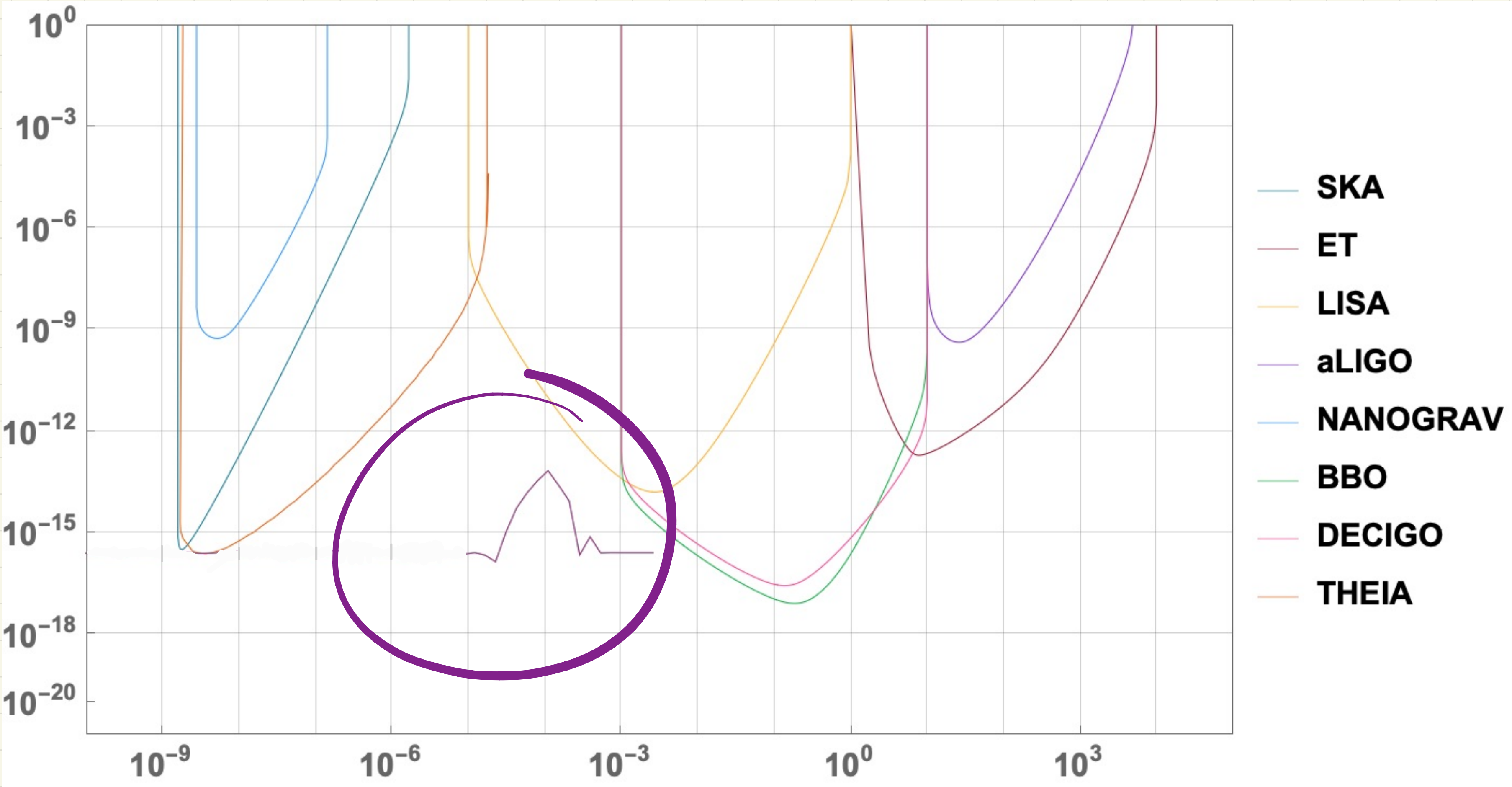
Gravitational Waves : $\psi''_{R,L} + \left(k^2 - \frac{2}{\eta^2} \right) \psi_{R,L} \simeq g(T, \varepsilon)$

Our Benchmark :

$f = 3,36 \times 10^{-2} M_{pe} \qquad g = 4 \cdot 10^{-3}$

$\lambda = 90$

Where are the shadows of this mechanism ?



We are exploring the phase space for the parameters...

STAY TUNED

Thank You