Backreaction of axion-SU(2) dynamics during inflation

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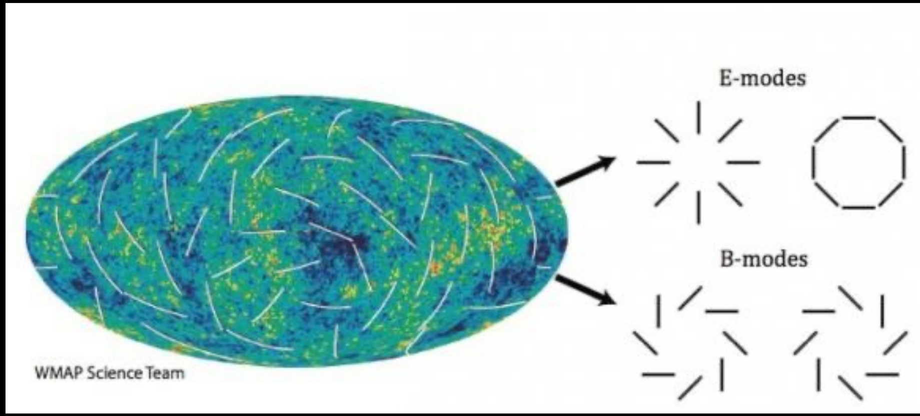
Signatures from gauge fields

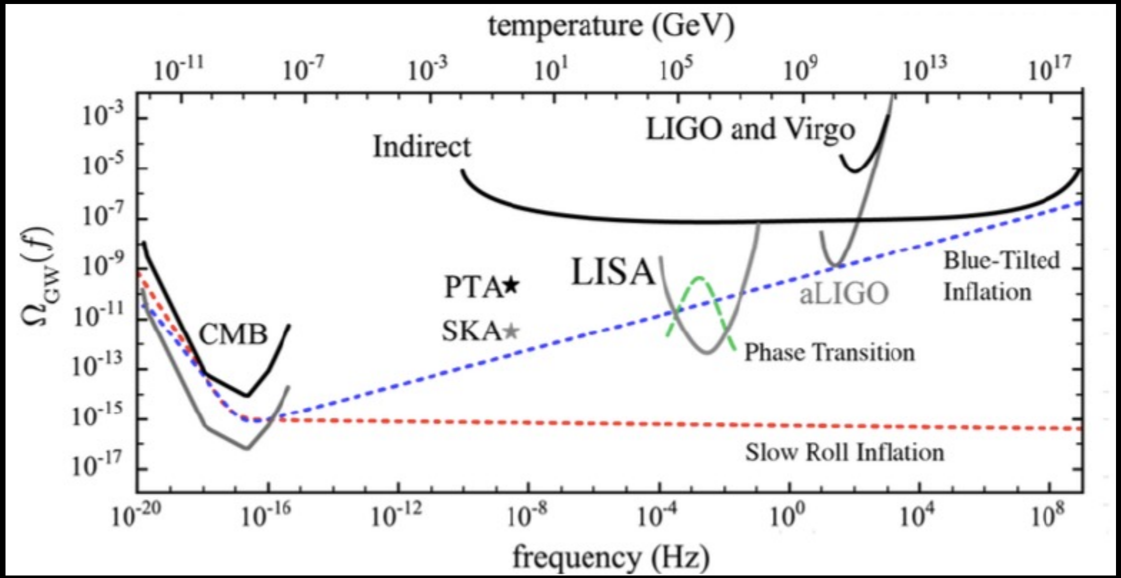
[WMAP]



- Polarization: B-modes
+ parity odd CMB correlations

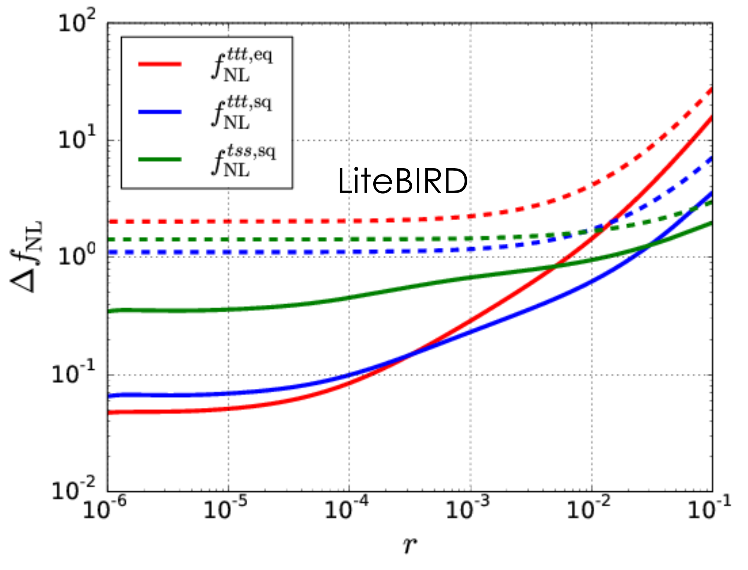
$TB \neq 0, EB \neq 0$

- Enhanced amplitude of GWs



[J. Garcia-Bellido]

- Non-zero tensor non-Gaussianity



[M. Shiraishi]

Spectator axion-SU(2) inflation

[P. Adshead , M. Wyman, 2012]

[E. Dimastrogiovanni, M. Fasiello, T. Fujita, 2017]

$$S = \int d^4x \sqrt{-\det(g_{\mu\nu})} \left[\frac{M_{\rm Pl}^2}{2} R - \frac{1}{2}(\partial\phi)^2 - V(\phi) - \frac{1}{2}\left((\partial\chi)^2 - \mu^4 \left(1 + \cos(\frac{\chi}{f}) \right) \right) - \frac{1}{4} F^a_{\mu\nu} F^{a\,\mu\nu} + \frac{\chi}{8f} \lambda F^a_{\mu\nu} \tilde{F}^{a\,\mu\nu} \right]$$

$$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu - g\epsilon^{abc} A^b_\mu A^c_\nu$$

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Isotropic solution for the background:

$$A^a_0 = 0,$$

$$A^a_i = \delta^a_i a(t) Q(t)$$

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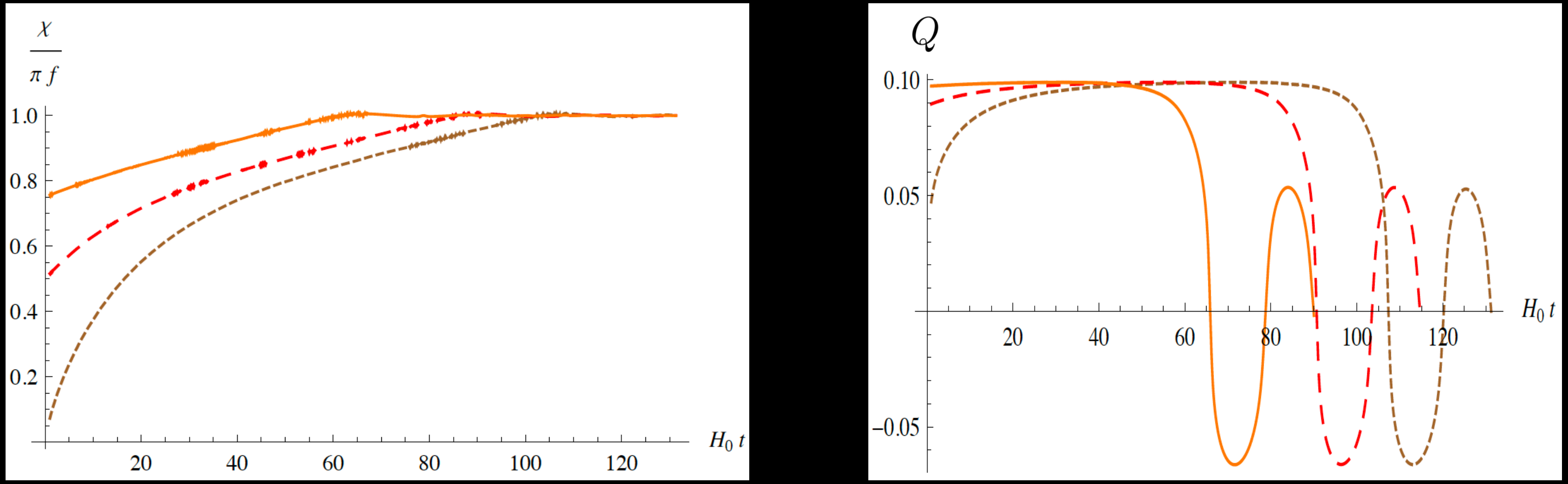

[A. Maleknejad, M.M. Sheikh-Jabbari, J. Soda]

Tensor perturbations source chiral gravitational waves

$$\psi''_{R,L} + \left(k^2 - \frac{2}{\eta^2}\right)\psi_{R,L} = f_1(T_{R,L}, m_Q, \dot{Q}, k, \eta)$$

$$T''_{R,L} + \left\{k^2 + \frac{2}{\eta^2}\left[m_Q\xi \pm k\eta(m_Q + \xi)\right]\right\}T_{R,L} = f_2(\psi_{R,L}, m_Q, \dot{Q}, k, \eta)$$

$$T_R \neq T_L \longrightarrow \psi_R \neq \psi_L$$

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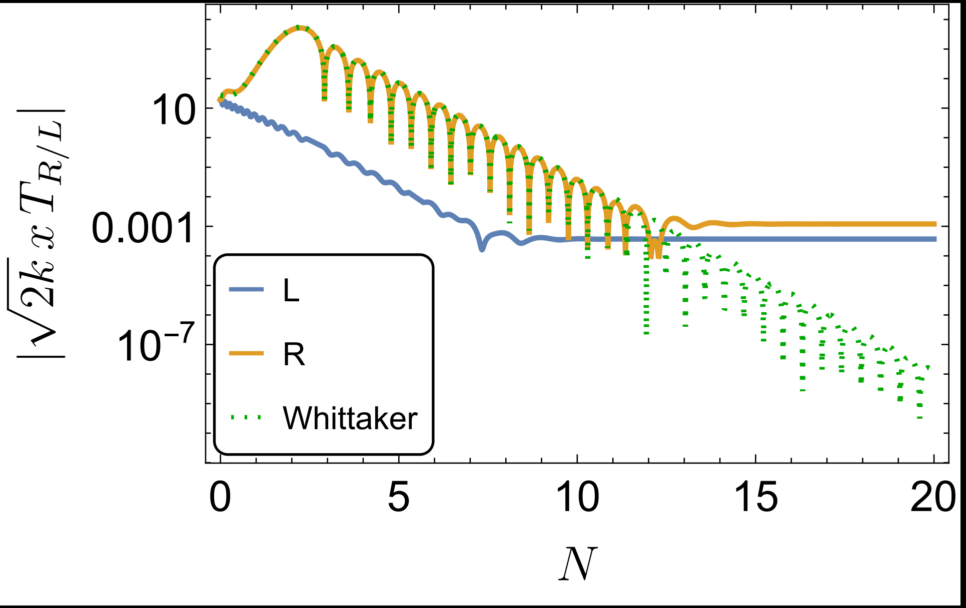
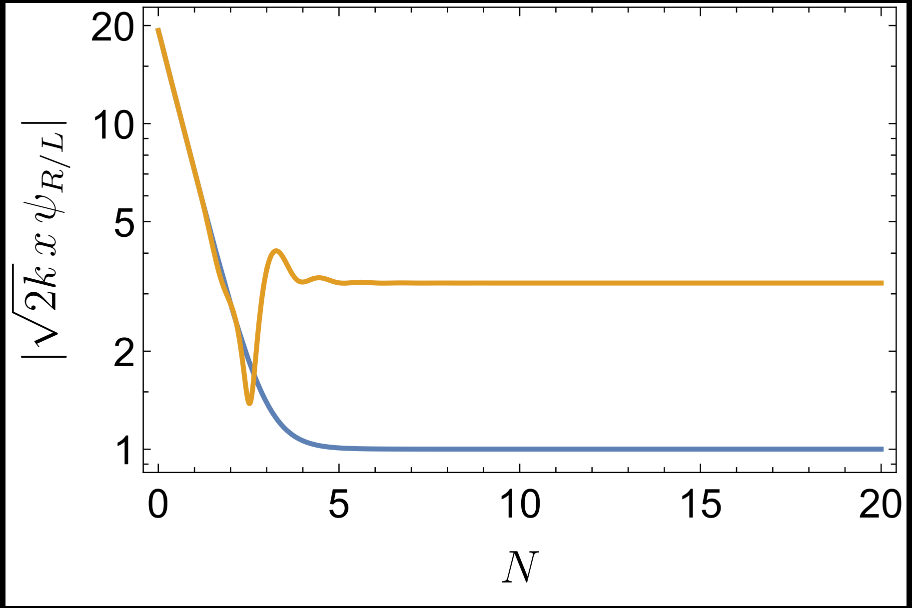
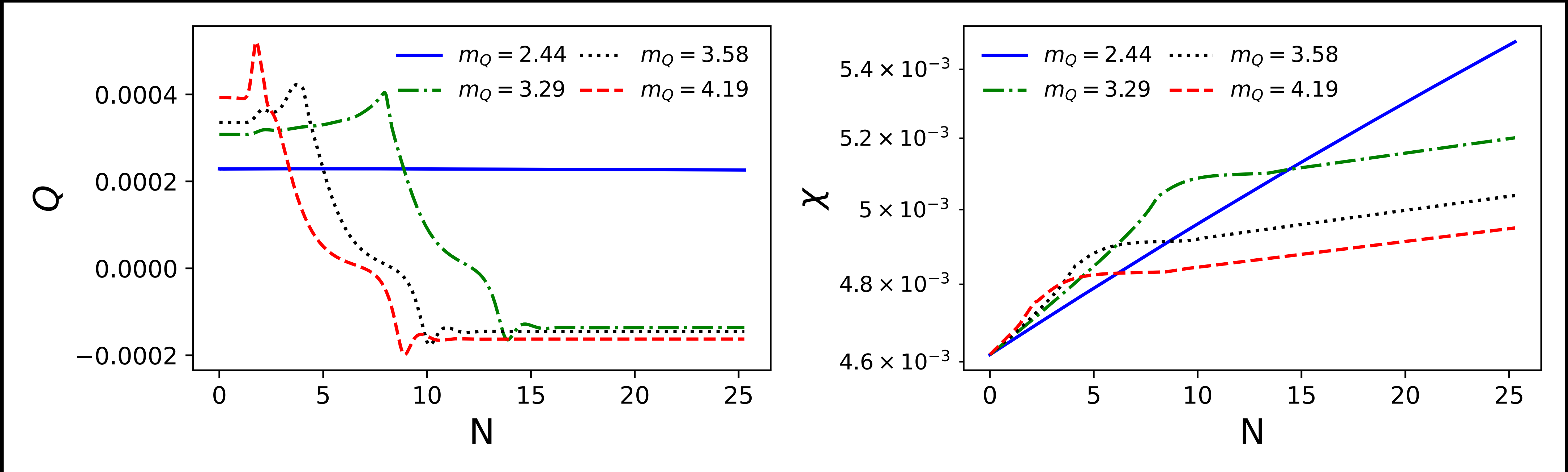




$$\mathcal{P}_h^{\rm tot}(k) = \mathcal{P}_h^{(s)}(k) + \mathcal{P}_h^{(v)}(k)$$

New dynamical attractor solution in the backreaction regime

[OI, E. I. Sfakianakis, R. Sharma, A. Brandenburg, 2023]



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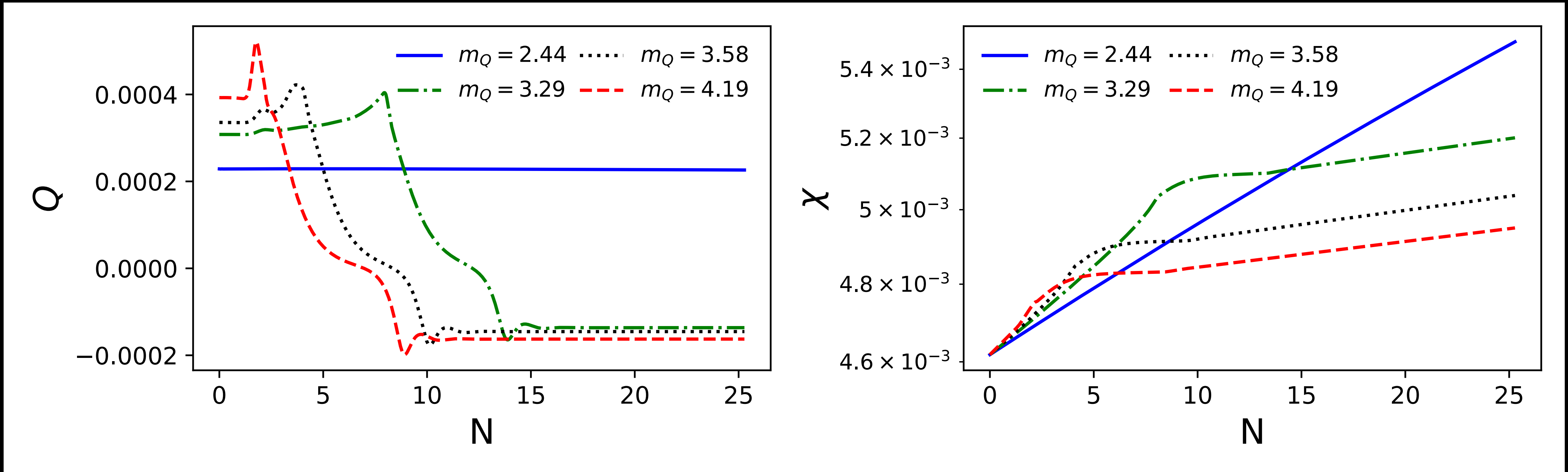


new solution:

$$\frac{\lambda}{af}\chi' \simeq -\frac{2H^2}{gQ}$$

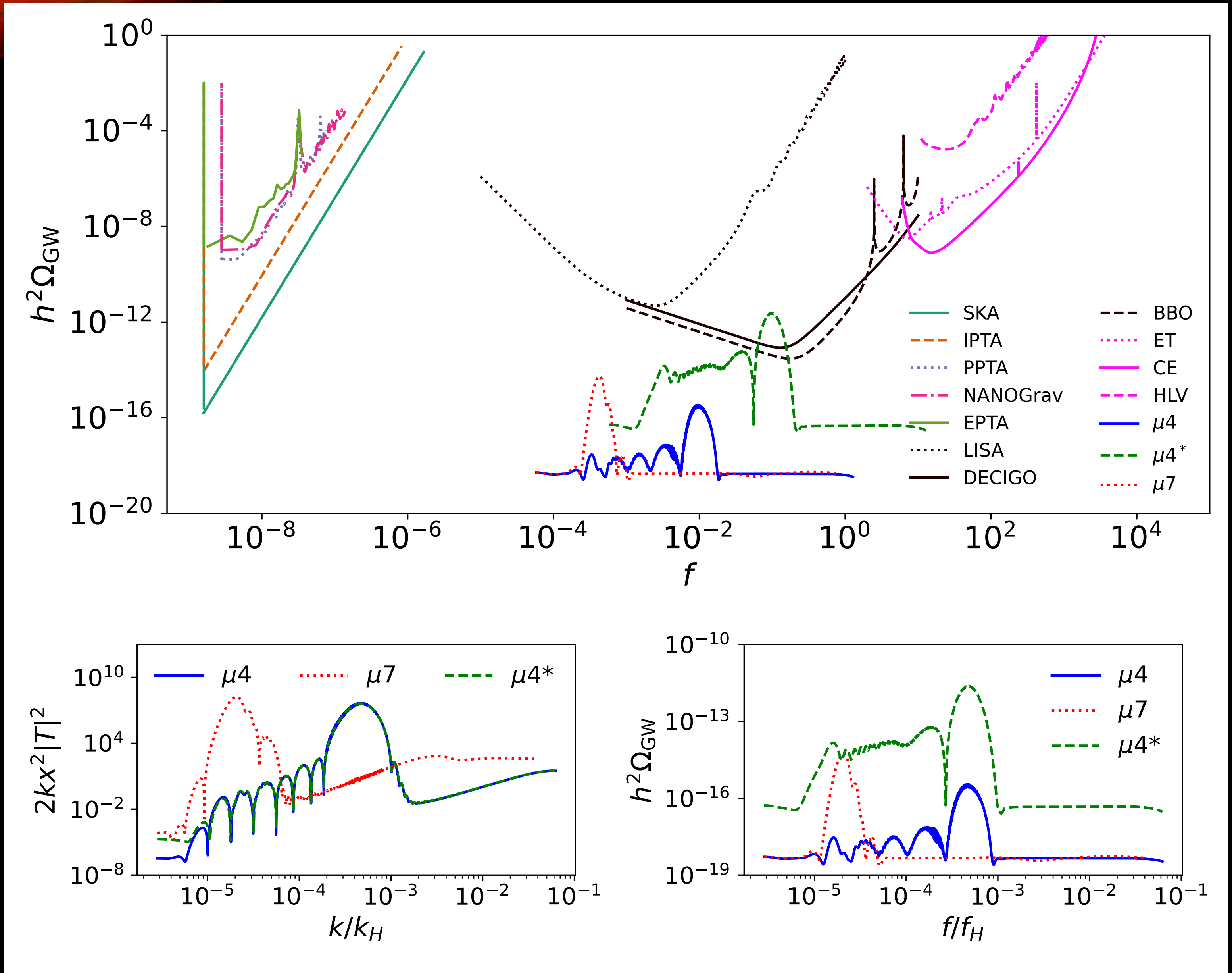
$$U_\chi = -\frac{3g\lambda}{f}HQ^3 + \frac{1}{\alpha}\left(4H^2Q + 2g^2Q^3\right)$$

resembles CNI solution:

$$\frac{\lambda}{af}\chi' = \cancel{2gQ} + \frac{2H^2}{gQ}$$

$$\cancel{\dot{Q}} = -HQ + \frac{f}{3g\lambda}\frac{U_\chi}{Q^2}$$

Oscillatory features in gravitational waves



$m_Q = 3.78, 5.15$

Summary

- A new dynamical attractor solution for the axion field and the vacuum expectation value of the gauge field, where the latter has an opposite sign with respect to the chromo-natural inflation solution.

- Phenomenology: redefining parts of the viable parameter space.

- Characteristic oscillatory features in the primordial gravitational wave background that are potentially detectable with upcoming gravitational wave detectors.

Summary

- A new dynamical attractor solution for the axion field and the vacuum expectation value of the gauge field, where the latter has an opposite sign with respect to the chromo-natural inflation solution.

- Phenomenology: redefining parts of the viable parameter space.

- Characteristic oscillatory features in the primordial gravitational wave background that are potentially detectable with upcoming gravitational wave detectors.

Thank you!

Back up slides

Homogeneous backreaction in axion-SU(2) inflation

[E. Dimastrogiovanni, M. Fasiello and T. Fujita, 2017]
[T. Fujita, R. Namba and Y. Tada, 2018]

$$Q'' + 2\mathcal{H}Q' + \left(\mathcal{H}' + \mathcal{H}^2\right)Q + 2g^2a^2Q^3 - \frac{g\lambda}{f}a\chi' Q^2 + a^2\mathcal{T}_{\rm BR}^{Q} = 0,$$

$$\chi'' + 2\mathcal{H}\chi' + a^2U_\chi(\chi) + \frac{3g\lambda}{f}aQ^2\left(Q' + \mathcal{H}Q\right) + a^2\mathcal{T}_{\rm BR}^{\chi} = 0,$$

$$\mathcal{T}_{\rm BR}^{Q} = \frac{g}{3a^2}\int\frac{d^3k}{(2\pi)^3}\left(\xi H - \frac{k}{a}\right)|T_R|^2,$$

$$\mathcal{T}_{\rm BR}^{\chi} = -\frac{\lambda}{2a^4 f}\frac{d}{d\eta}\int\frac{d^3k}{(2\pi)^3}\left(a\, m_Q H - k\right)|T_R|^2$$

- Homogeneous backreaction
- Assumption $\dot{H} = 0$

The Pencil Code

a high-order finite-difference code for compressible MHD

[A. Brandenburg, A. Johansen, P. Bourdin, W. Dobler, W. Lyra et al.]