

Primordial **gravitational waves** revealed by a **spinning axion**

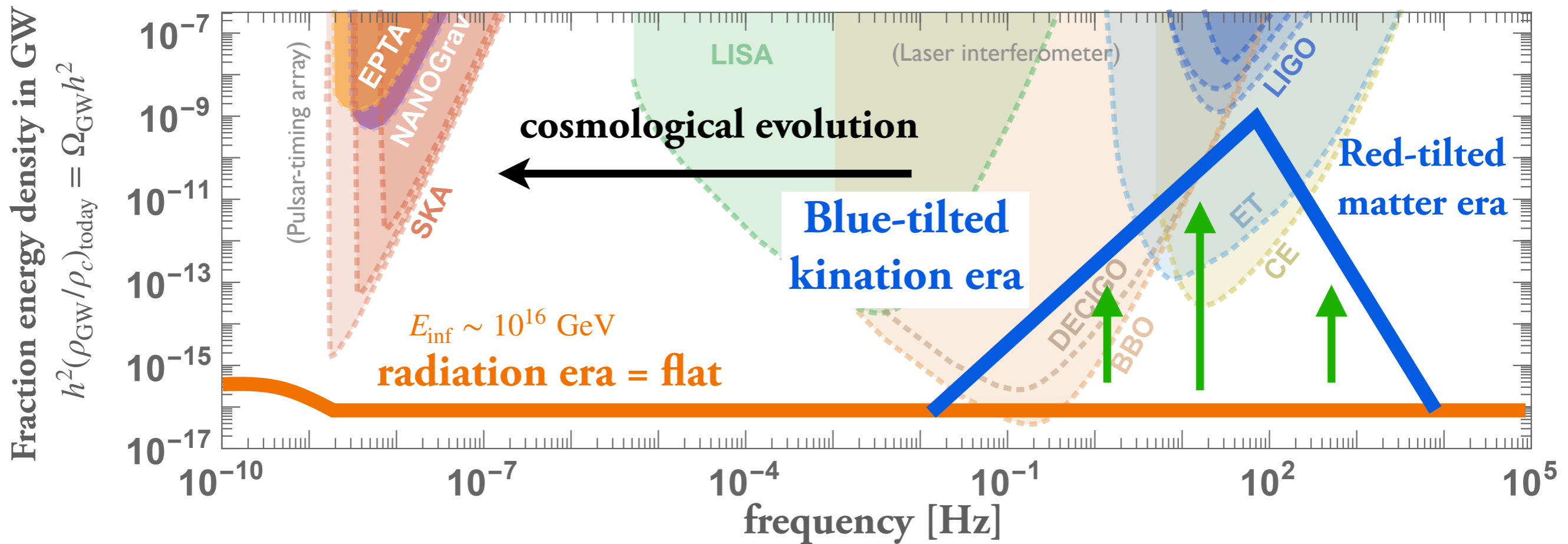
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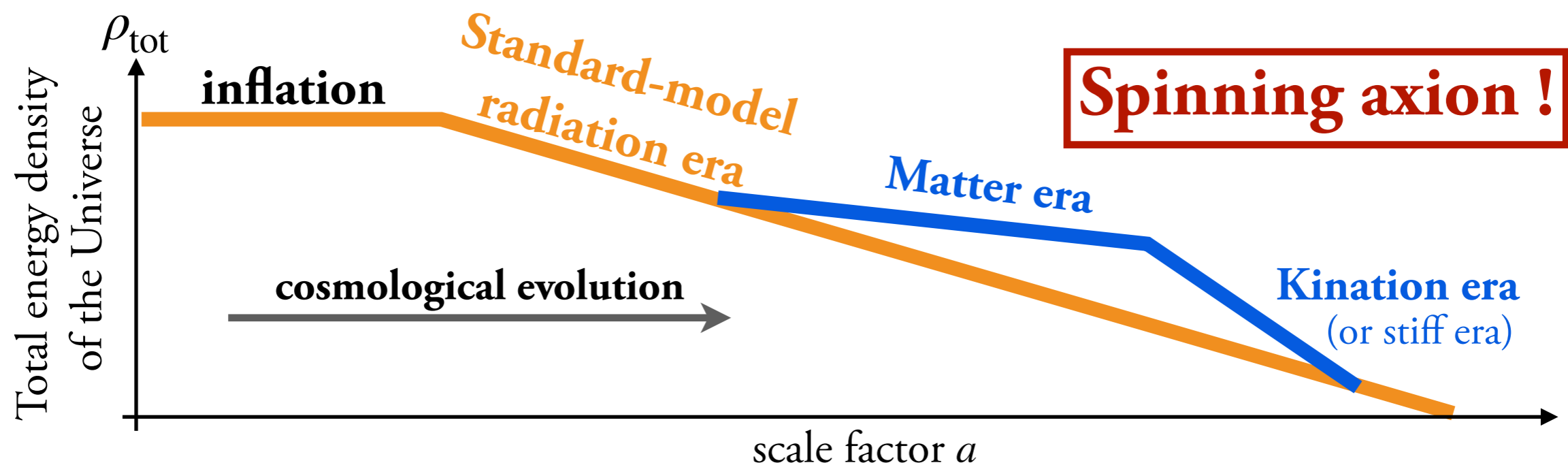
with Yann Gouttenoire (Tel Aviv U.), Géraldine Servant (UHH/DESY)
(To appear)

Invisibles21 PhD forum, 03.06.2021

Irreducible GW background from quantum fluctuation during inflation is typically small.



Spectral distortion of the primordial GW provide a hint of the cosmological history.



Going **beyond** the assumption of **vanishing velocity of axion**.

e.g. **Kinetic-misalignment (Axiogenesis / Trapped-misalignment)**

[Harigaya et al, '19 '20] [Chang & Cui, '19] [Di Luzio, Gavela, Quilez, Ringwald, '21]

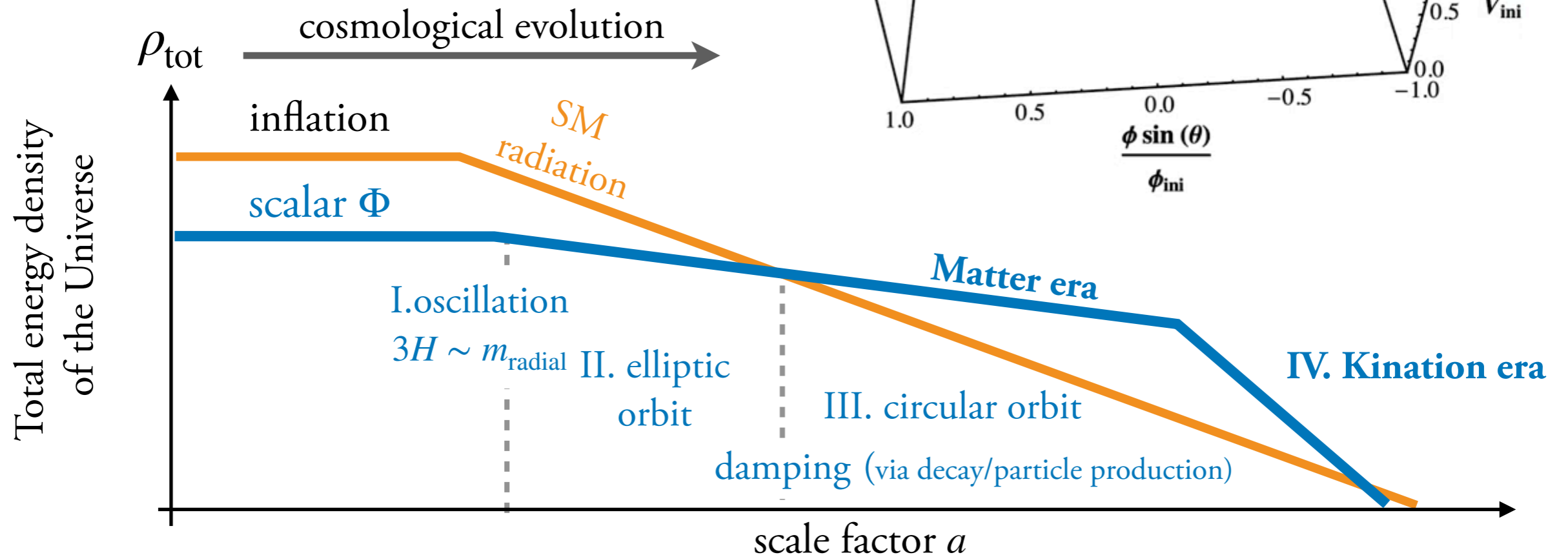
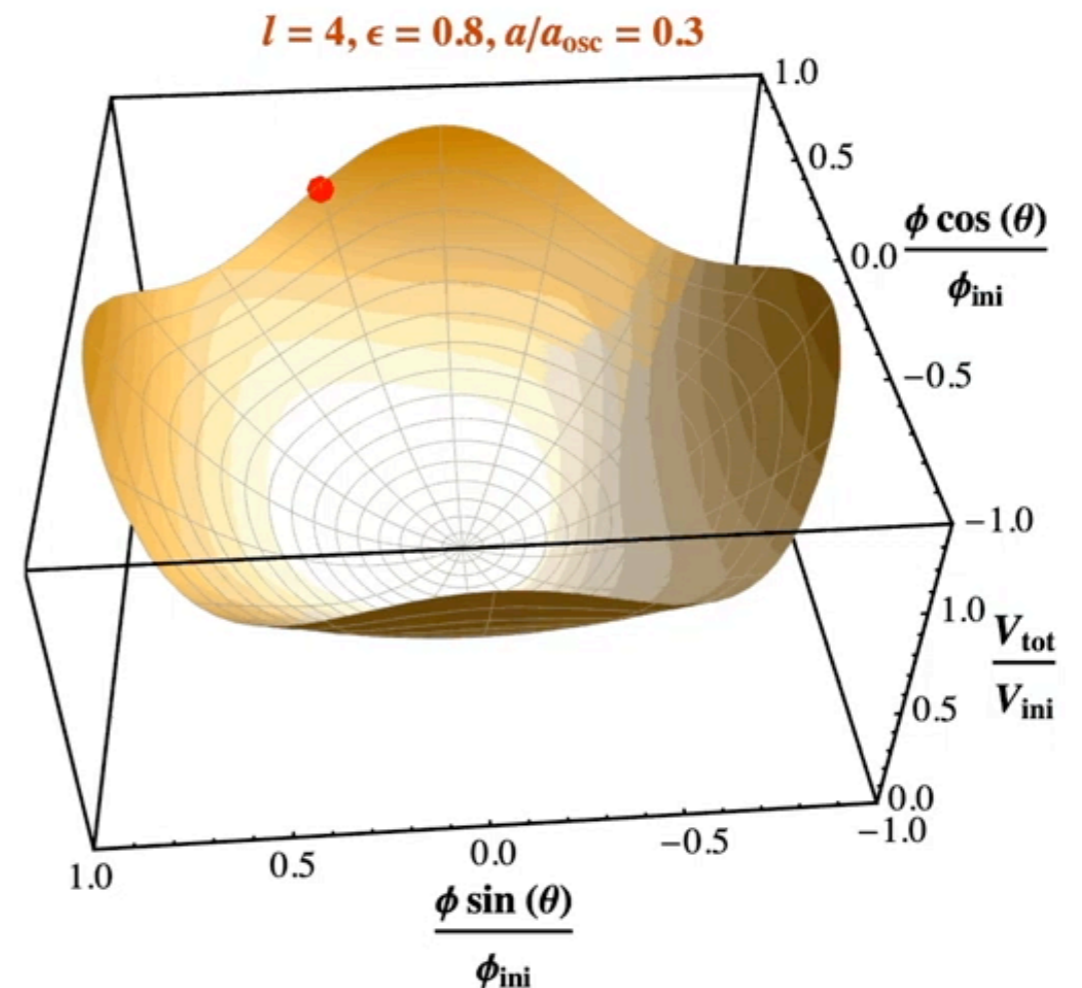
Talk by Pablo Quílez

Example: spinning scalar field

with $U(1)$ -symmetry: $\Phi \sim \phi e^{i\theta}$

Radial mode ϕ oscillates in potential
with **mass m_{radial}**

Angular mode θ “axion” spins,
(kicks by a mild explicit $U(1)$ -breaking.)



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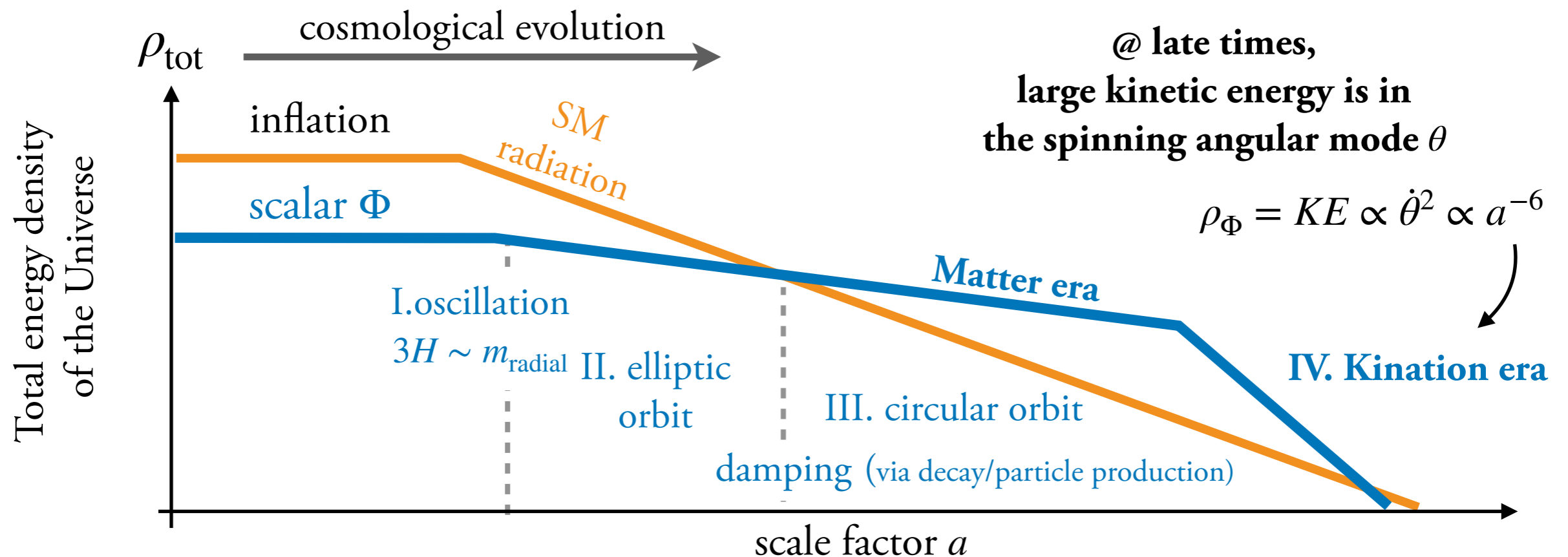
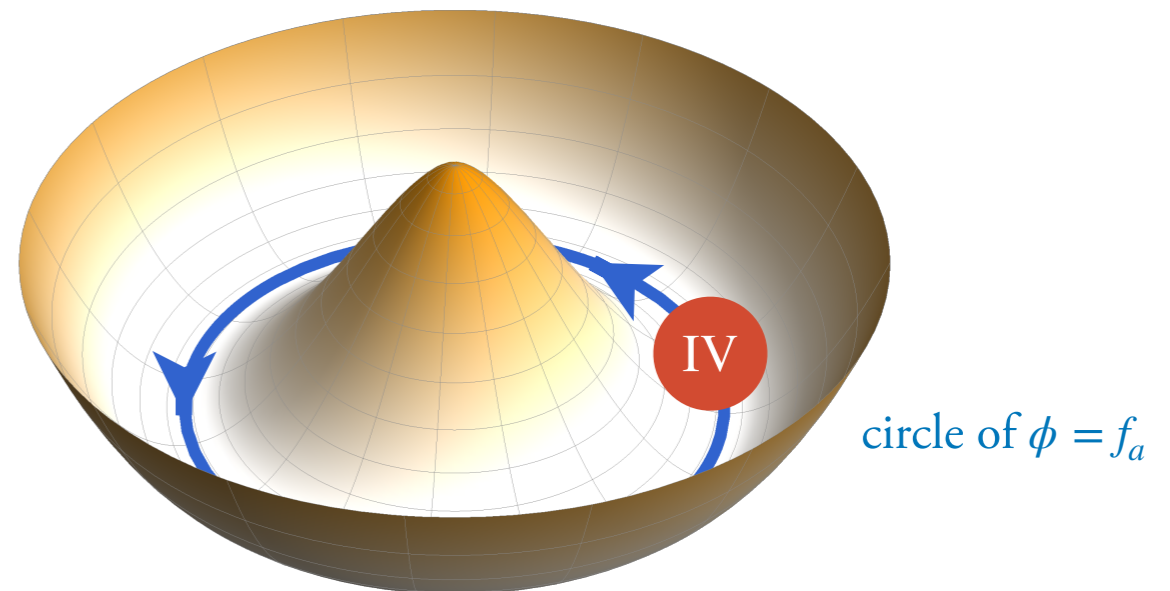
Talk by Pablo Quílez

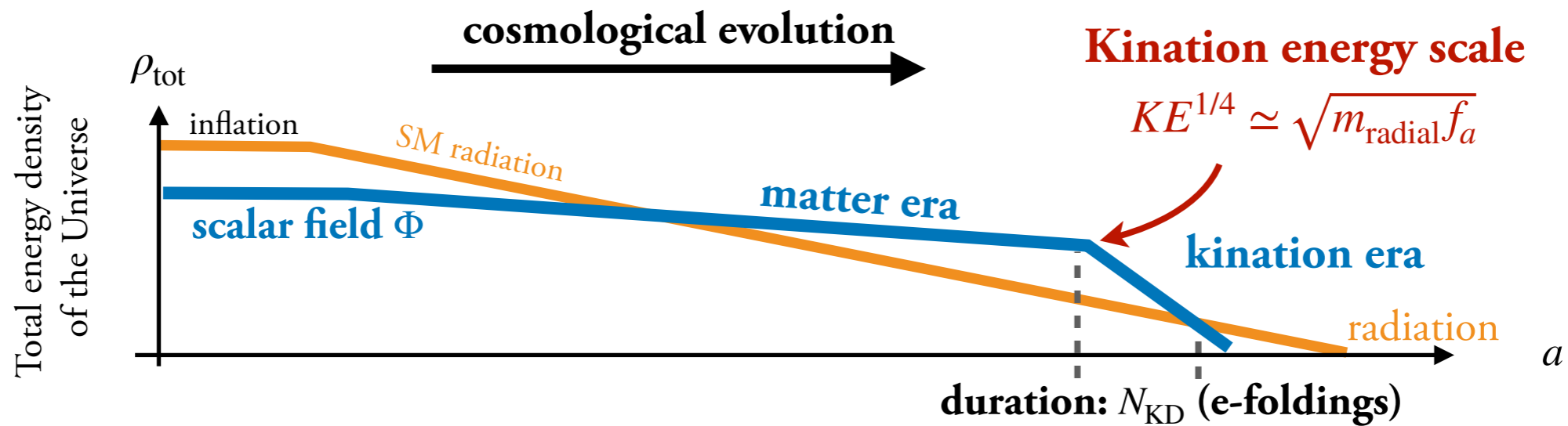
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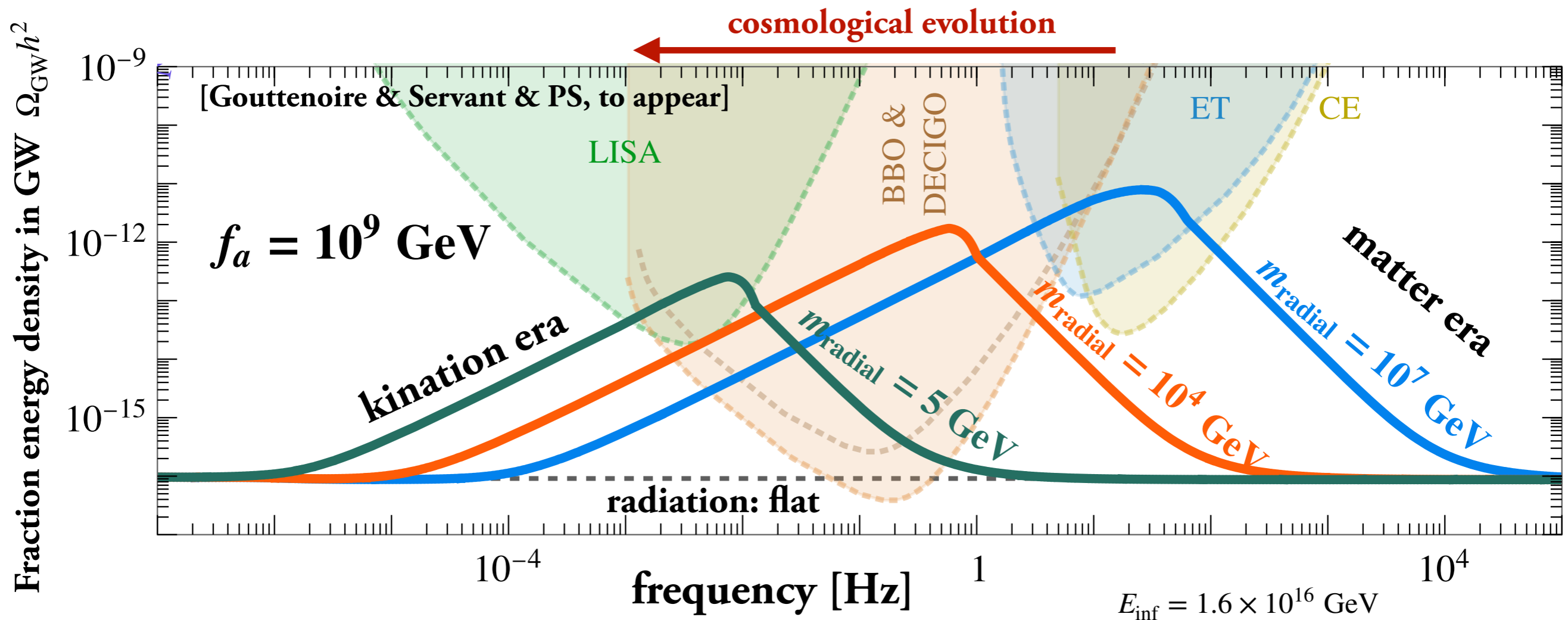
Peak frequency: $f_{\text{peak}} \approx 10 \text{ Hz} \left(\frac{\sqrt{m_{\text{radial}} f_a}}{10^8 \text{ GeV}} \right) \left[\frac{\exp(N_{\text{KD}}/2)}{10} \right]$

“Peaked GW signature”

ET & CE probes $\sim 10^8 \text{ GeV}$ kination

Peak amplitude: $\Omega_{\text{peak}} h^2 \approx 10^{-12} \left(\frac{E_{\text{inf}}}{1.6 \times 10^{16} \text{ GeV}} \right)^4 \left[\frac{\exp(2N_{\text{KD}})}{10^4} \right]$

LISA probes $\sim 10 \text{ TeV}$ kination



In summary...

Any GW from early times are **amplified** by a **kination** era
 — induced by a scalar field with large kinetic energy.

e.g. inflationary GW spectrum gets **blue-tilted**.
 (We also look at a peak in cosmic-string GW spectrum.)

A spinning axion

e.g. from complex scalar field (generic in SM extensions)

can generate a **short and low-scale kination** during the pre-BBN epoch.

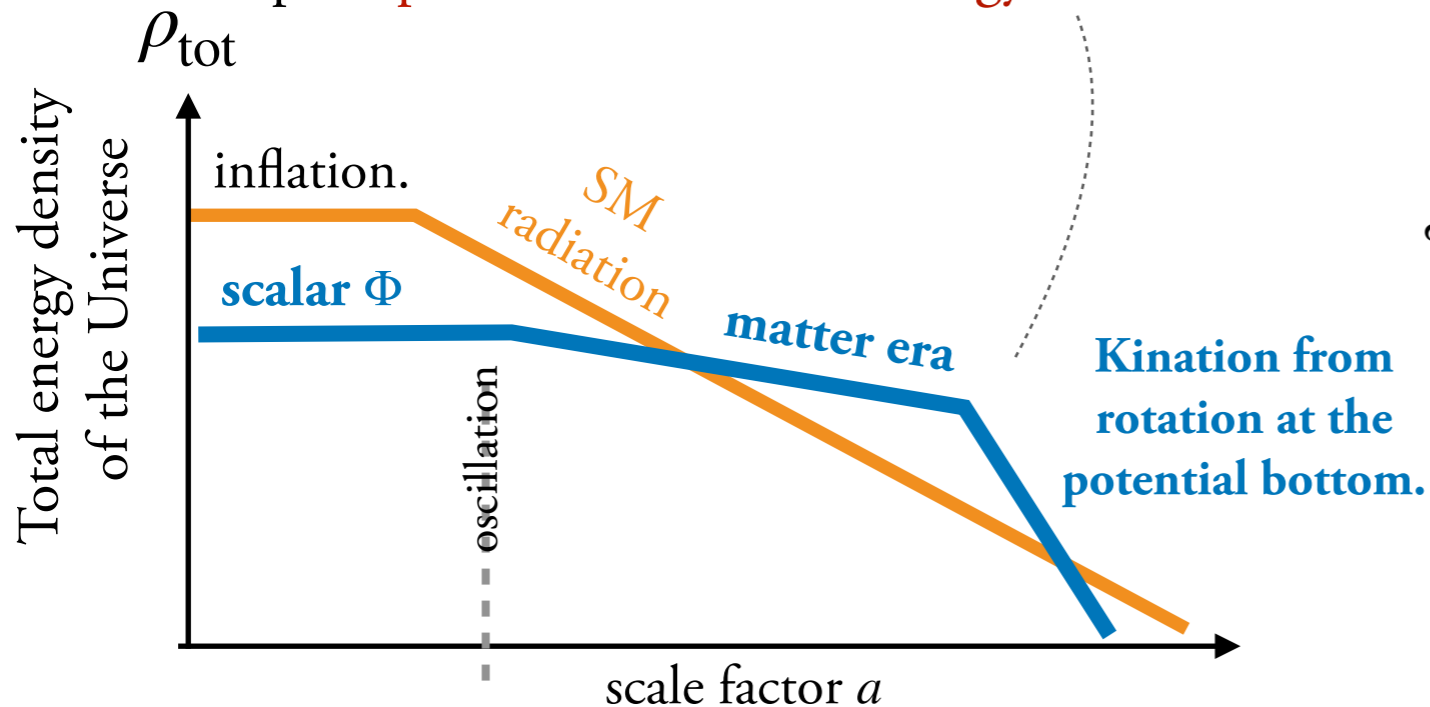
(Axion kinetic misalignment or Affleck-Dine mechanism)

“Peaked GW signature”

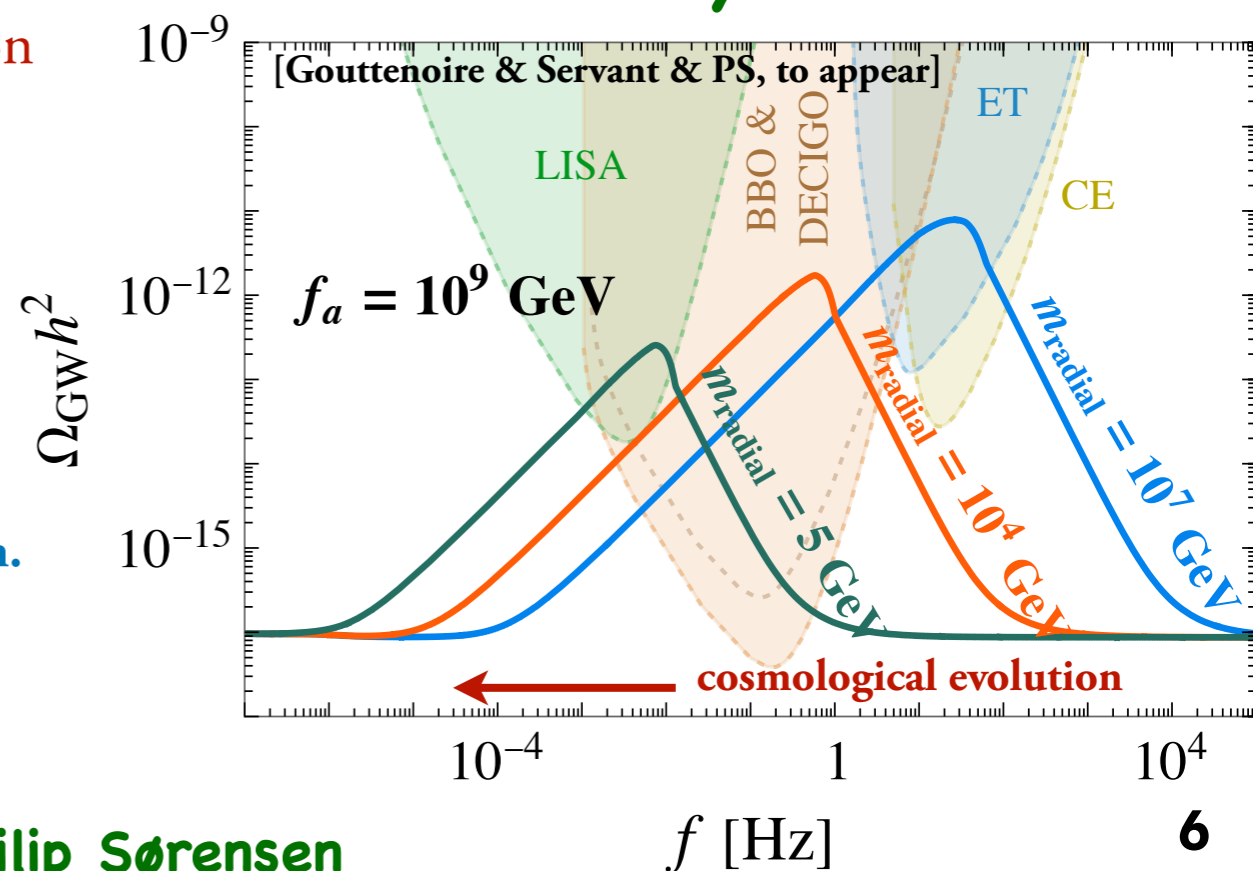
LISA for $\sqrt{m_{\text{radial}} f_a} \sim 10$ TeV kination | ET & CE for $\sqrt{m_{\text{radial}} f_a} \sim 10^8$ GeV kination.

GW peak **amplitude** \propto kination **duration**

GW peak **position** \propto kination **energy scale & duration**



Thank you !



Related to DM prod., see the poster/videos by Philip Sørensen