

# Dark matter from axion fragmentation

Moving the ALP Dark Matter window into testable territory with axion fragmentation

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Cem Erönçel (DESY)

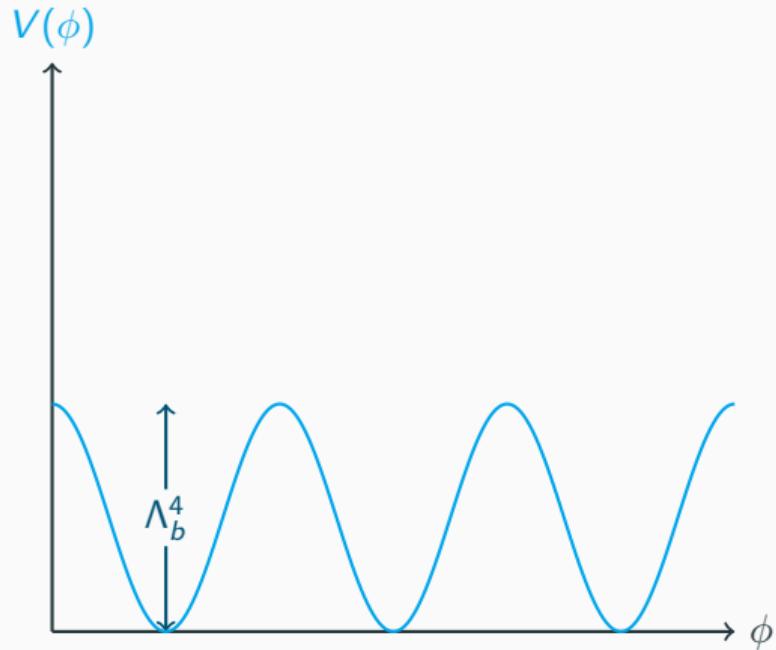
22.09.2020, DESY Virtual Theory Forum 2020

In collaboration with Ryosuke Sato, Géraldine Servant, and Philip Sørensen



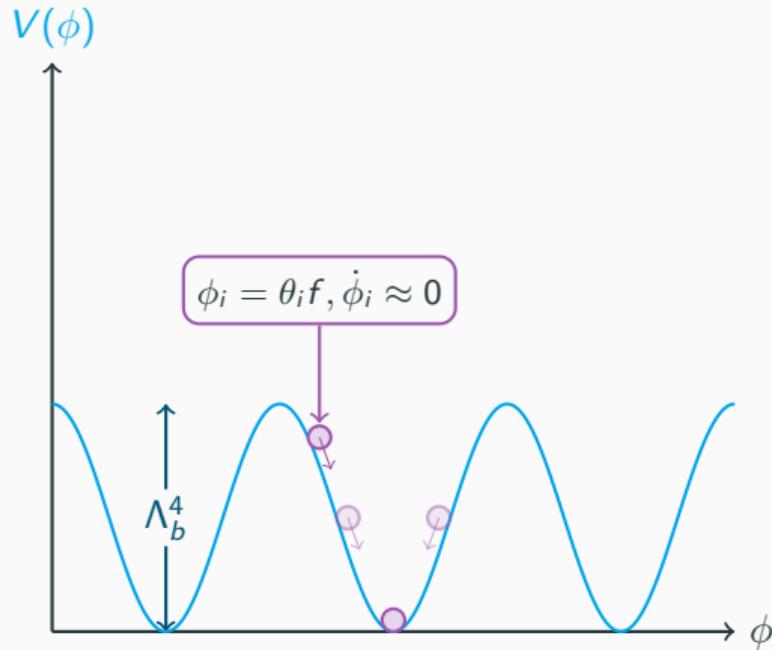
## Misalignment mechanism vs. Axion fragmentation

$$\mathcal{L}_{\text{ALP}} \supset \frac{1}{2} \partial_\mu \phi \partial^\mu \phi - \Lambda_b^4 \cos\left(\frac{\phi}{f}\right), \quad \Lambda_b^4 = m^2 f^2$$



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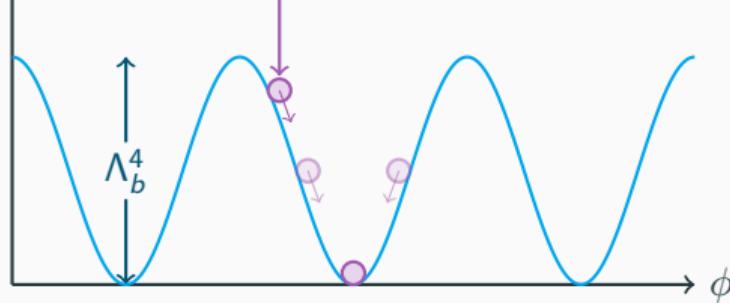
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$V(\phi)$

Fluctuations are negligible unless  $\theta_i - \pi \ll 1$

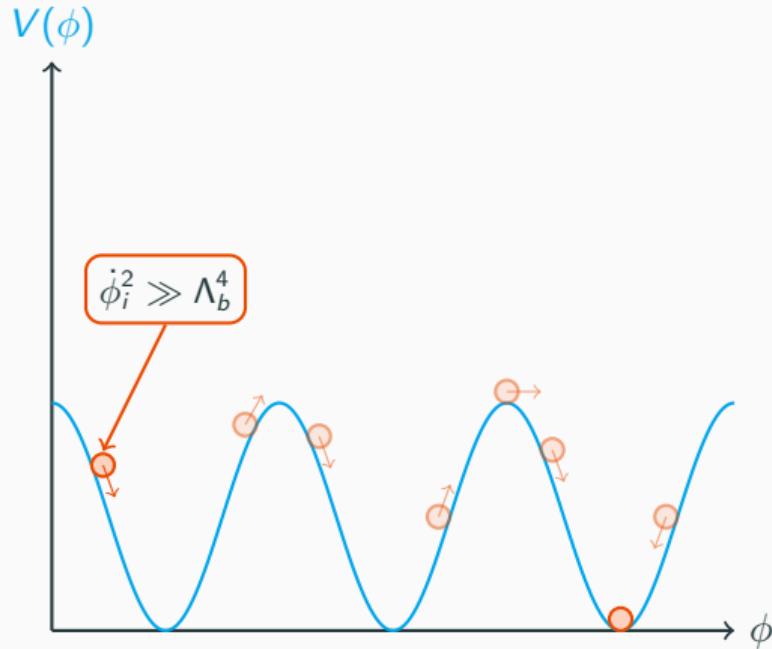
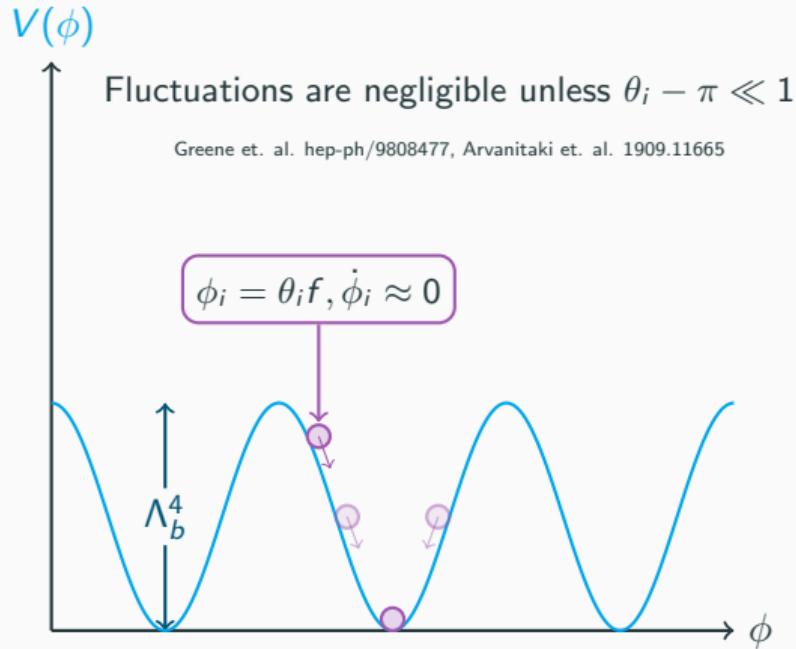
Greene et. al. hep-ph/9808477, Arvanitaki et. al. 1909.11665

$$\phi_i = \theta_i f, \dot{\phi}_i \approx 0$$



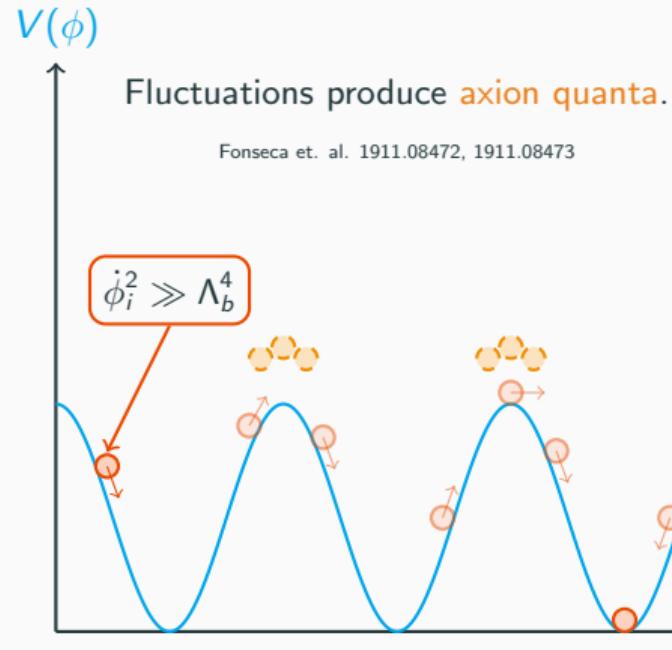
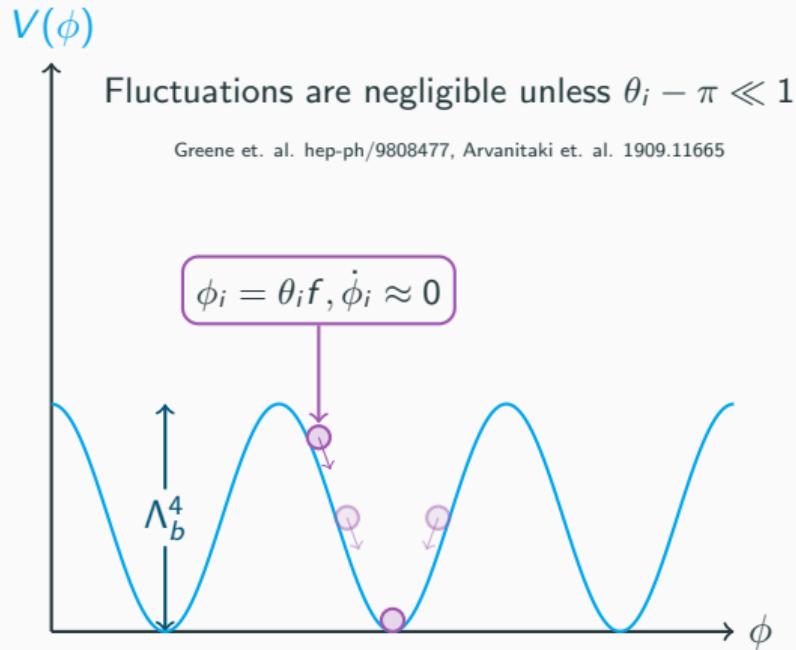
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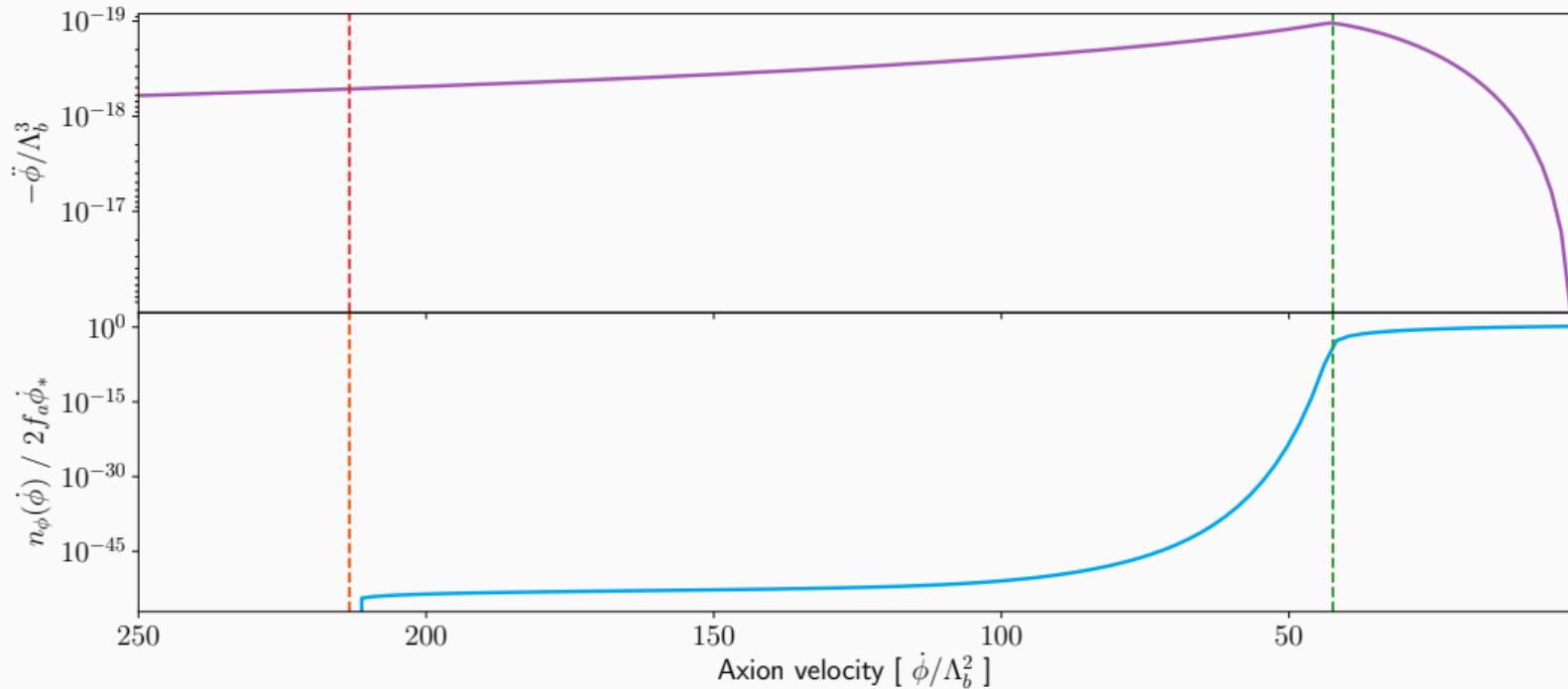


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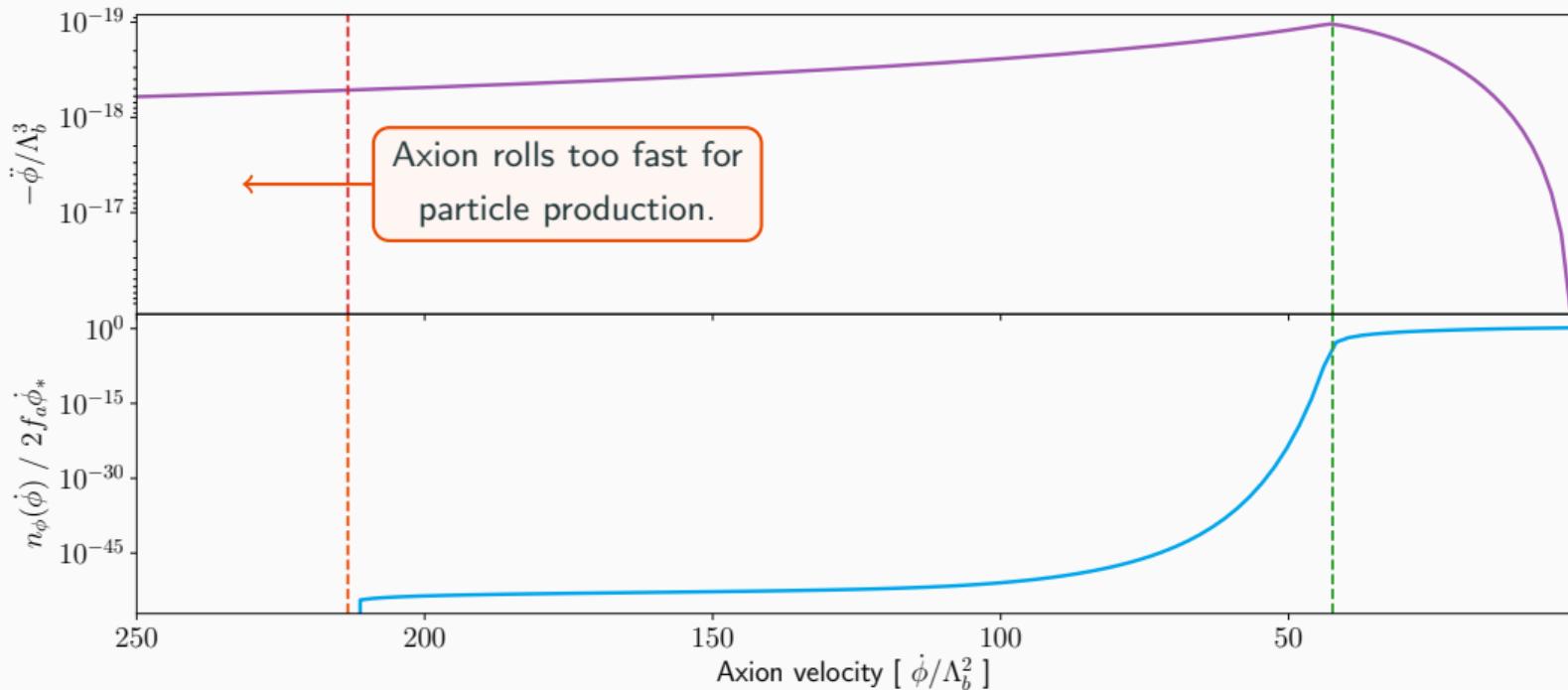
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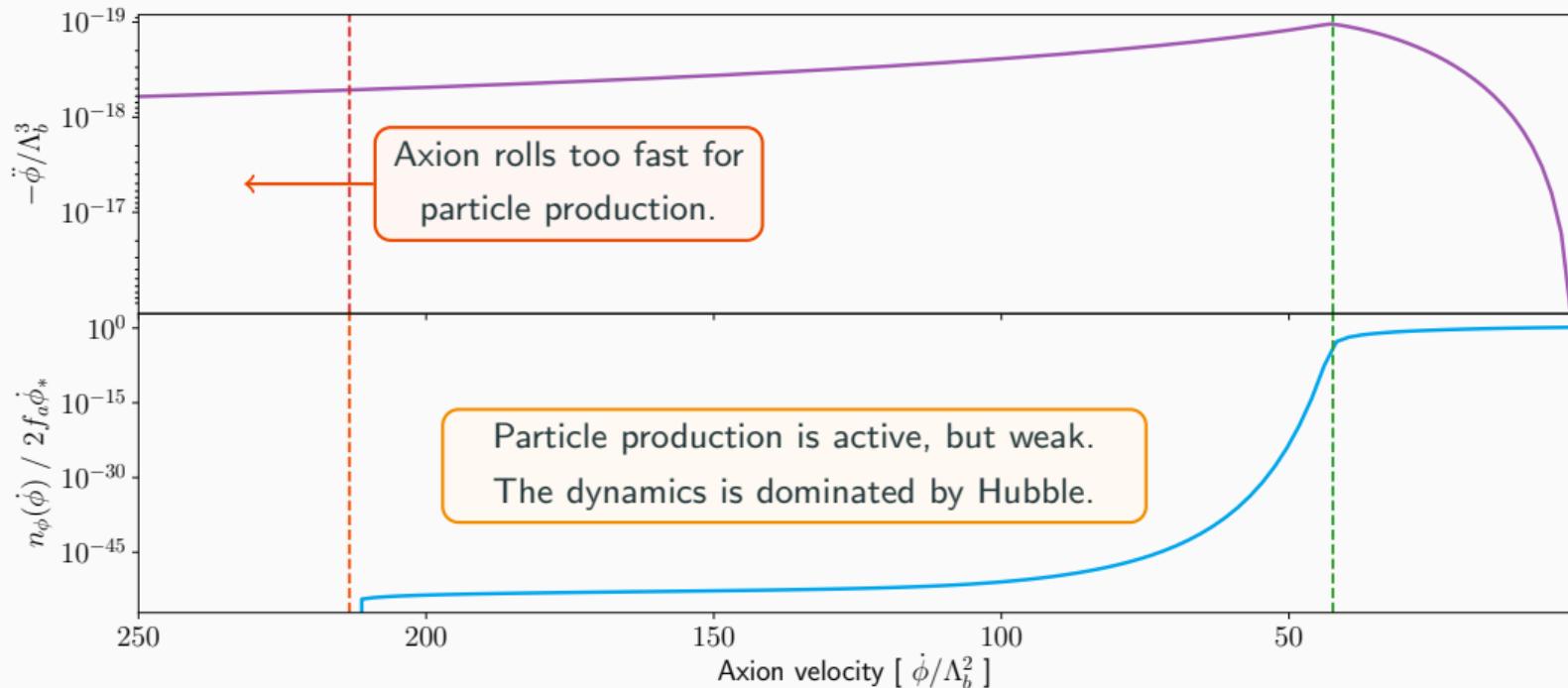
## Axion fragmentation in a nutshell



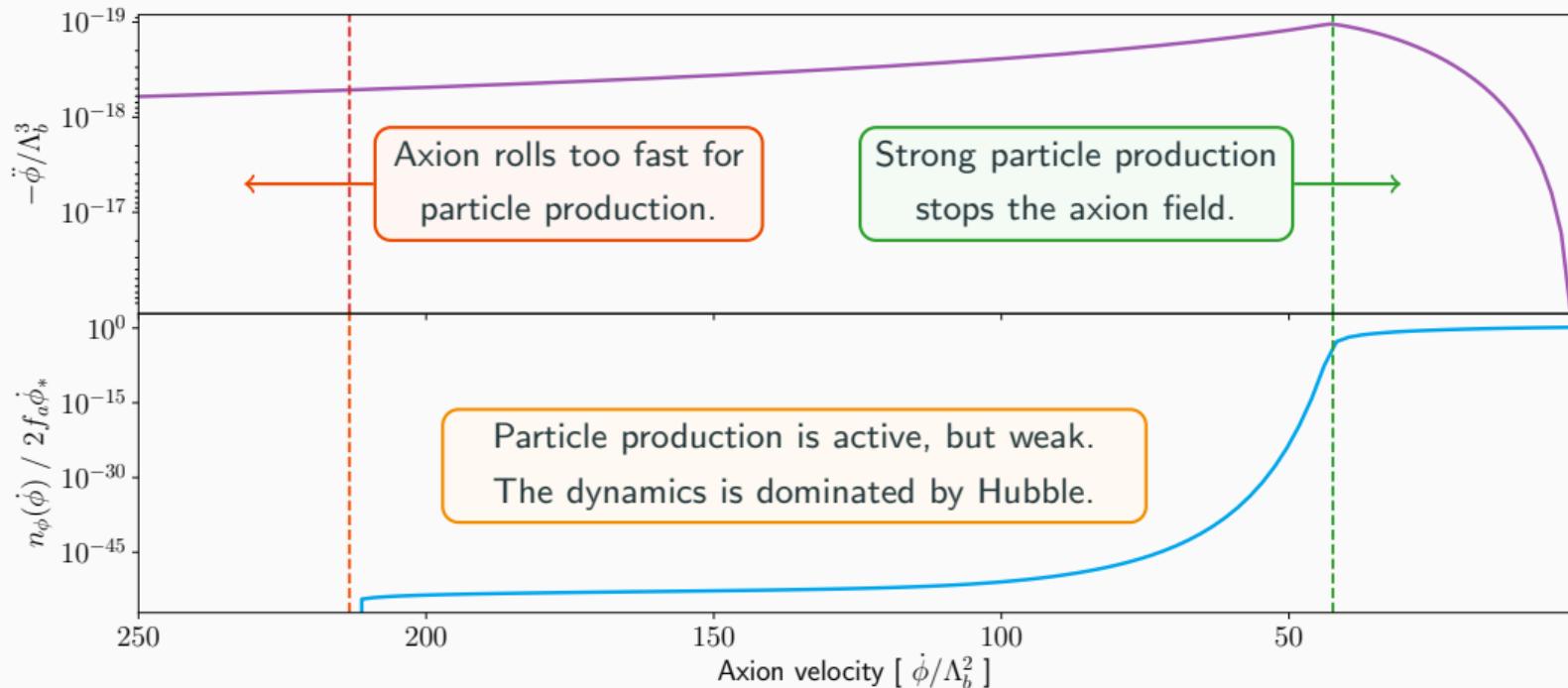
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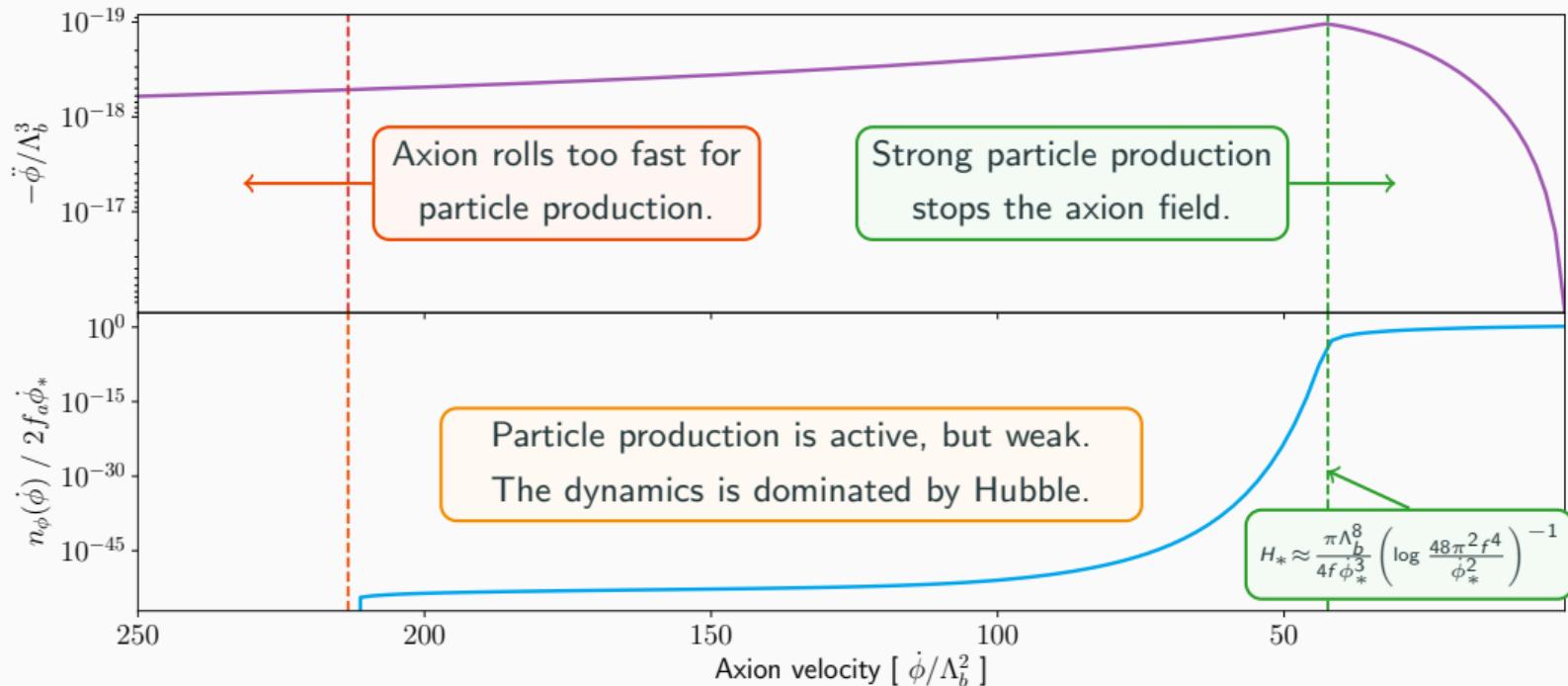
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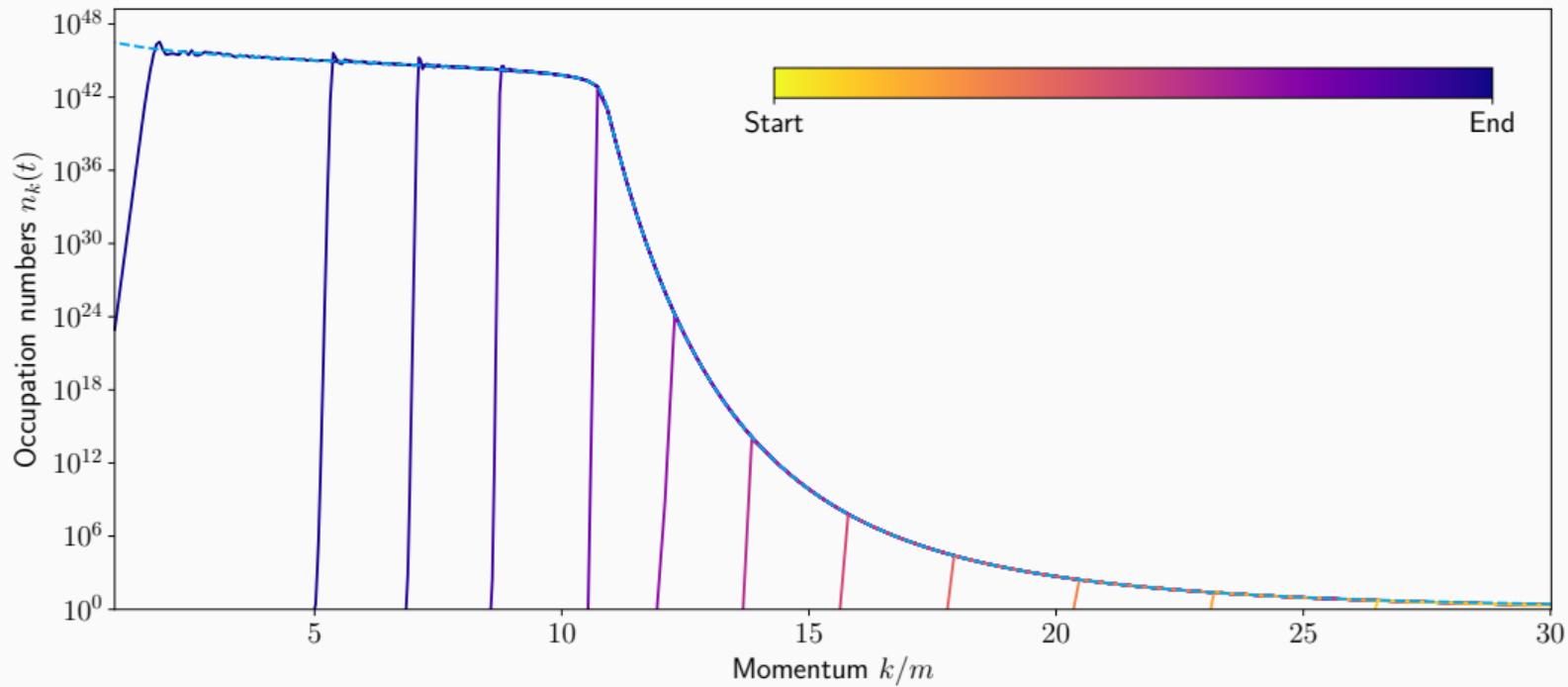
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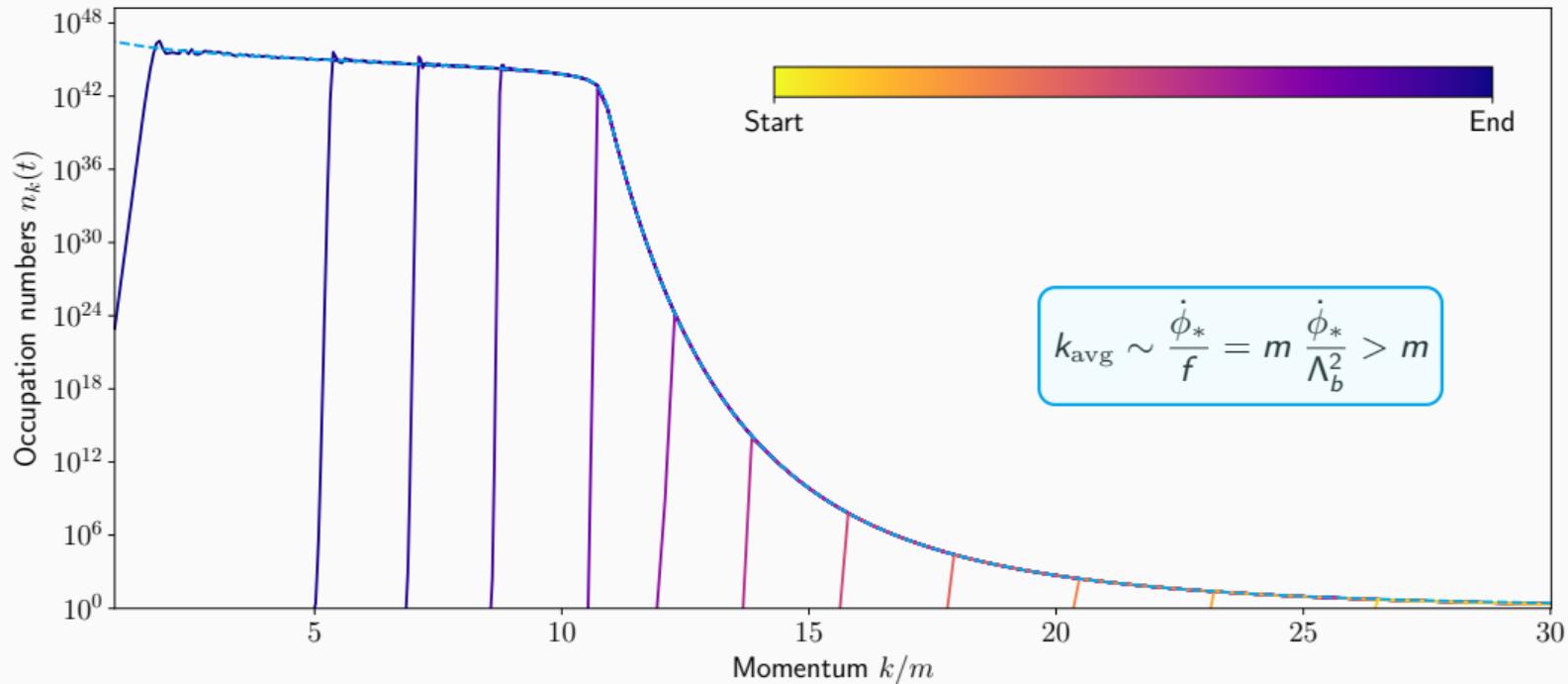
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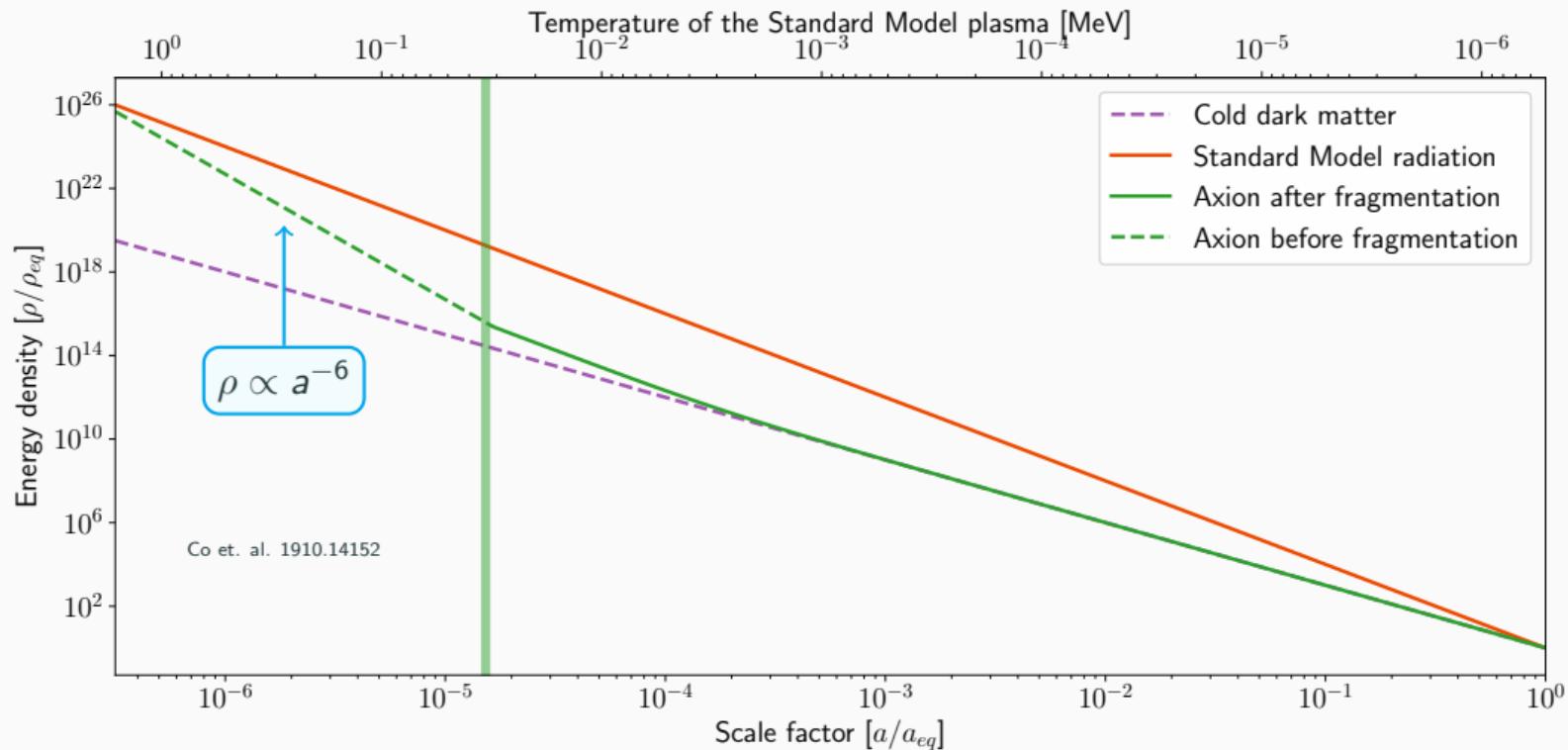
## Momentum distribution



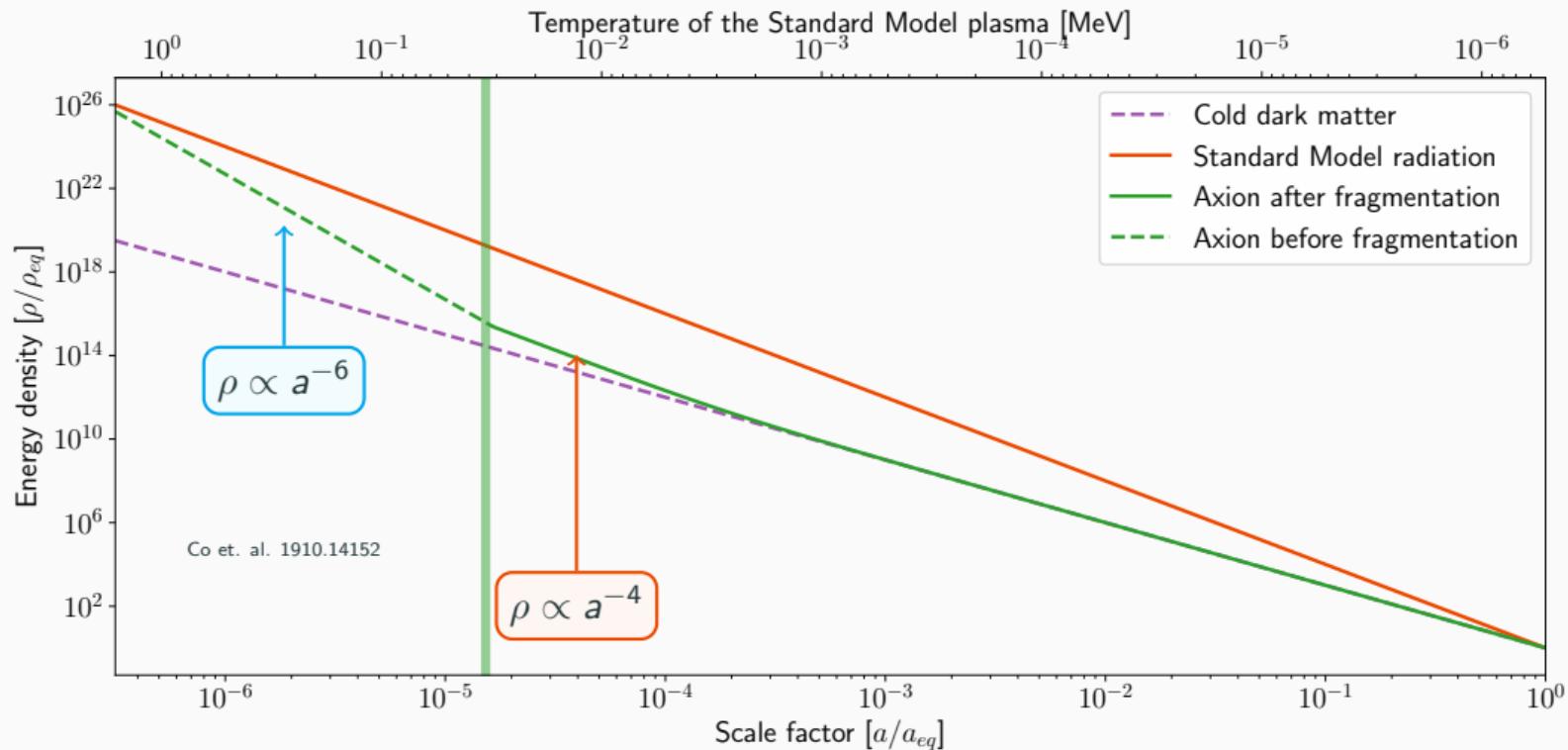
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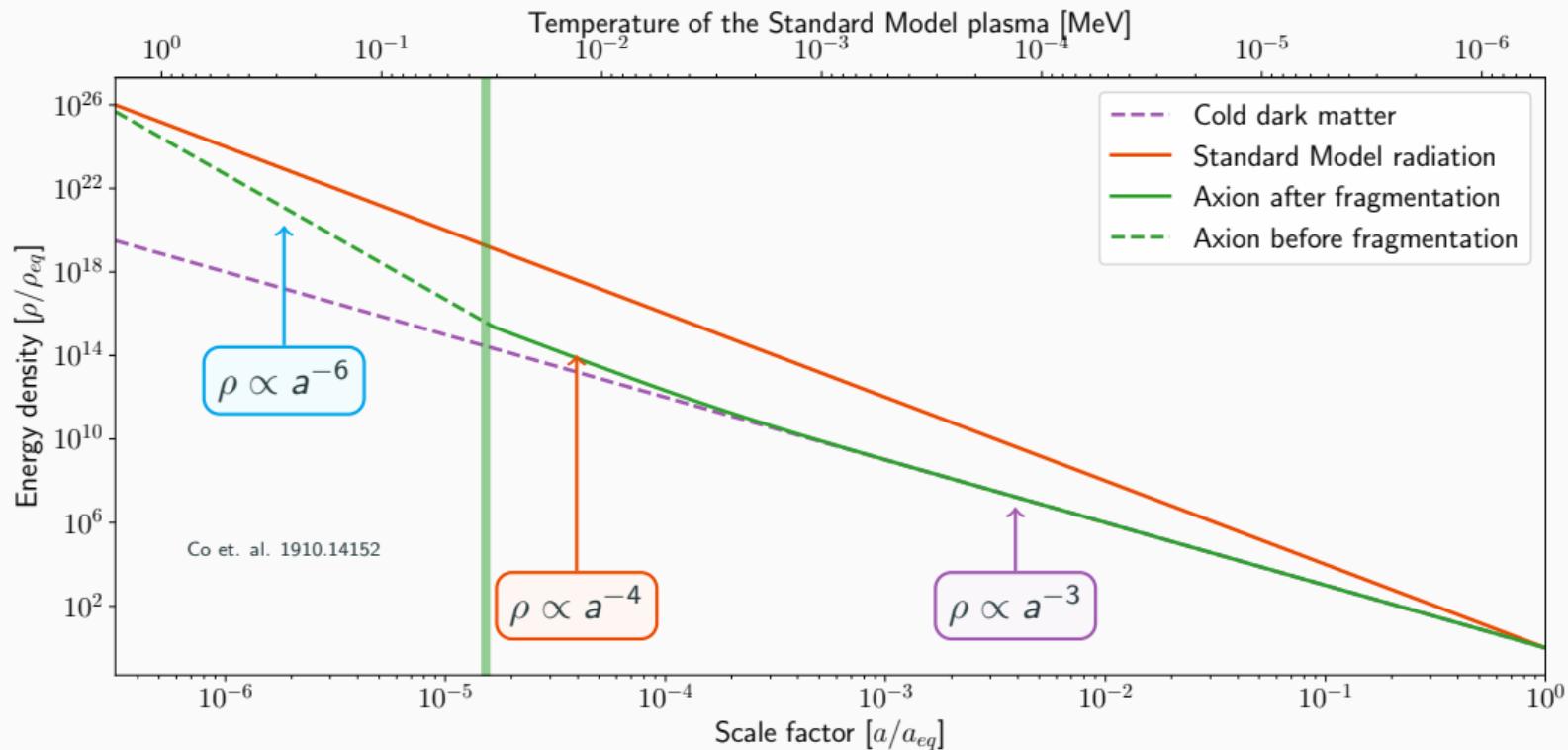
# Evolution of the axion energy density



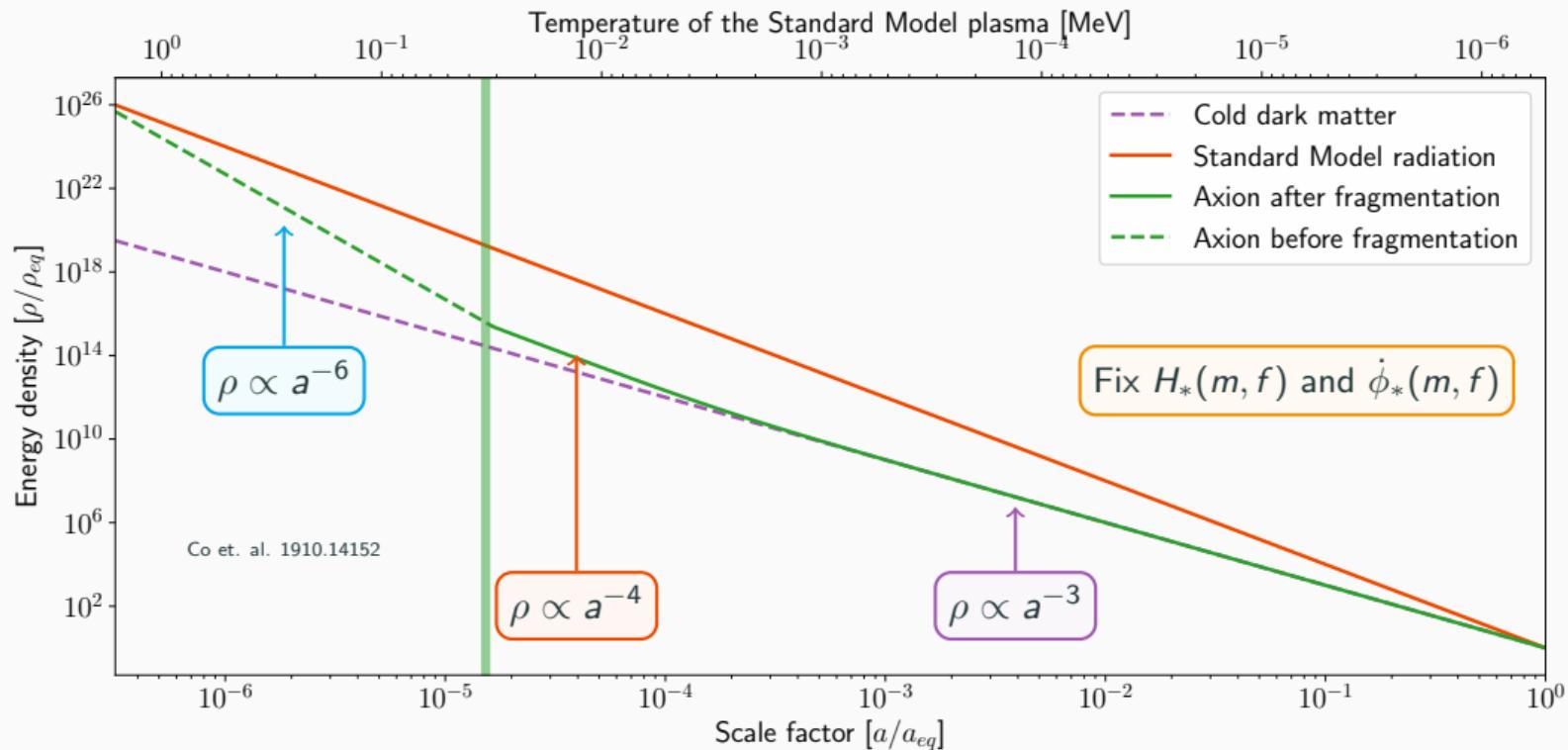
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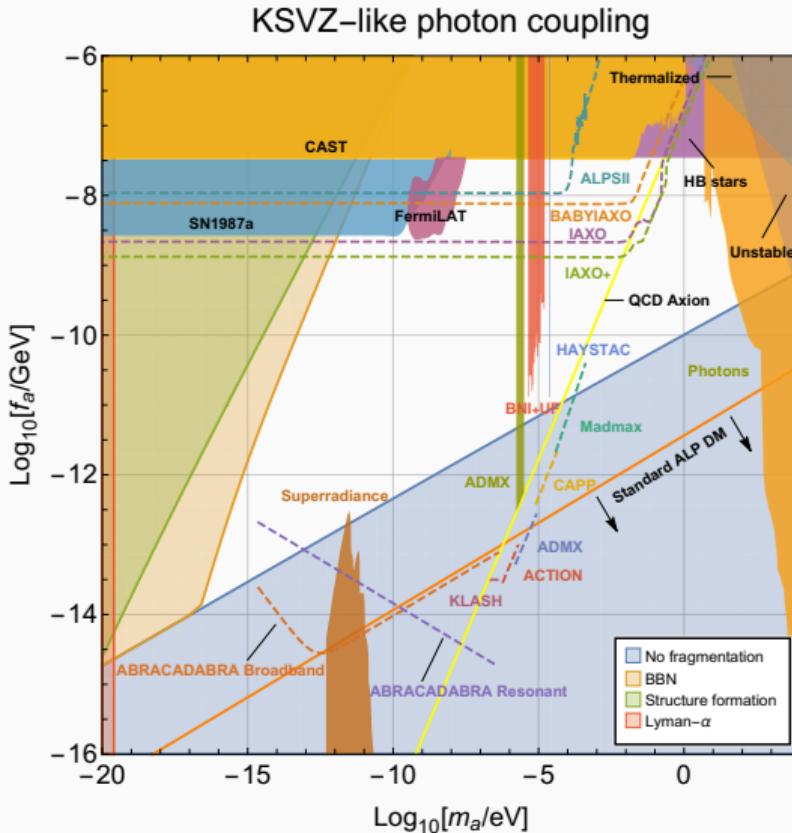
# Evolution of the axion energy density



# Evolution of the axion energy density



# ALP parameter space with axion fragmentation



## Conclusions

- Quantum fluctuations of an ALP field can play a **major role**, if it starts with a large **kinetic energy**, so that it goes over many wiggles before it stops.
- The produced axion quanta are **relativistic** at production, but they can **cool down** to produce all of the dark matter.
- This mechanism pushes the ALP dark matter window to **lower** values of the axion decay constant, which is testable by many experiments including **ALPSII**, IAXO, and MADMAX.

# Thank you!

## Contact:

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# Temperature at fragmentation

