16^{th} Patras workshop on axions, WIMPs and WISPs

17^{th} June 2021

Thermal axions with multi-eV masses are possible in low-reheating scenarios

Based on
PC, M. Lattanzi, A. Mirizzi and F. Forastieri,
arXiv:2104.03982 [astro-ph.CO]

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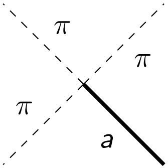
Thermal axion production

T. Moroi and H. Murayama, Phys. Lett. B **440** (1998), 69-76

L. Di Luzio *et al.*, Phys. Rept. **870** (2020), 1-117

Hadronic axions are produced by pion interactions



$$\mathcal{L}_{a\pi} = \frac{C_{a\pi}}{f_\pi f_a}(\pi^0\pi^+\partial_\mu\pi^- + \pi^0\pi^-\partial_\mu\pi^+ - 2\pi^+\pi^-\partial_\mu\pi^0)\partial^\mu a$$

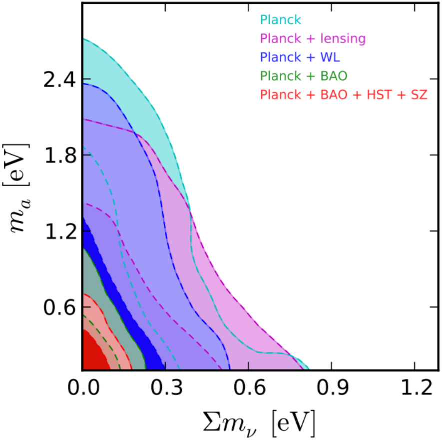
where

- f_a is the Peccei-Quinn scale
- $f_\pi = 92.4\,\mathrm{MeV}$ is the pion decay constant
- $C_{a\pi} = \frac{1-z}{3(1+z)}$, $z = m_u/m_d \simeq 0.48$

The cosmological axion bound

E. Di Valentino *et al.*, Phys. Lett. B **752** (2016), 182-185

Axions are Hot Dark Matter: constraints from $N_{\rm eff} \sim 3.046$ and $\Omega_h h^2 \lesssim 2 \times 10^{-3}$

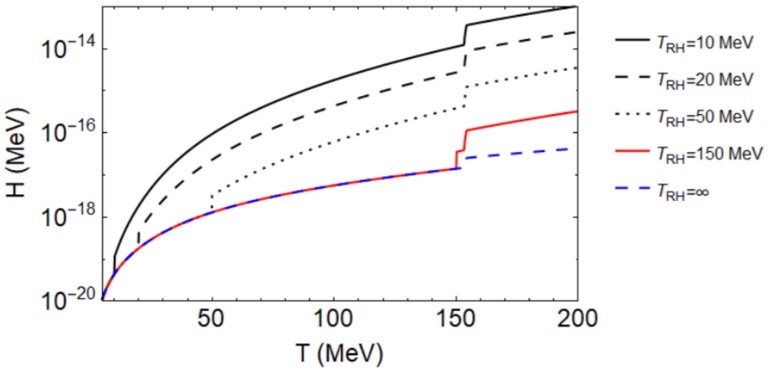


Constraint on the axion mass: $m_a \lesssim 0.53$ eV

Low-reheating cosmologies

D. Grin *et al.*, Phys. Rev. D **77** (2008), 085020

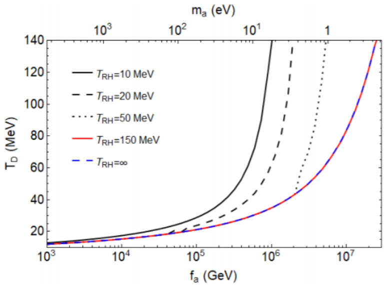
The inflaton decay into Standard Model particles happens at T_{RH}



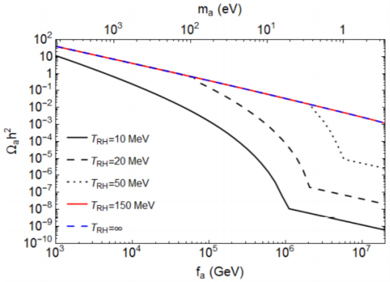
The reheating temperature might be as low as $T_{\mathrm{RH}} \sim 5\,\mathrm{MeV}$
P. F. de Salas *et al.*, Phys. Rev. D **92** (2015) no.12, 123534

The axion mass bound in LTR cosmologies

The axion relic density is diluted by the faster cosmic expansion



Decoupling temperature vs f_a



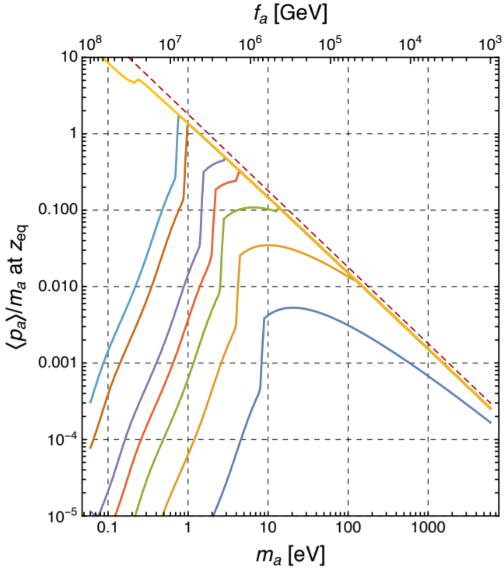
Axion density vs f_a

A recent work questioned the validity of the $\pi\pi \to \pi a$ rate calculation for $T_{\rm D} \gtrsim 60\,\text{MeV}$

L. Di Luzio, G. Martinelli and G. Piazza, [arXiv:2101.10330 [hep-ph]].

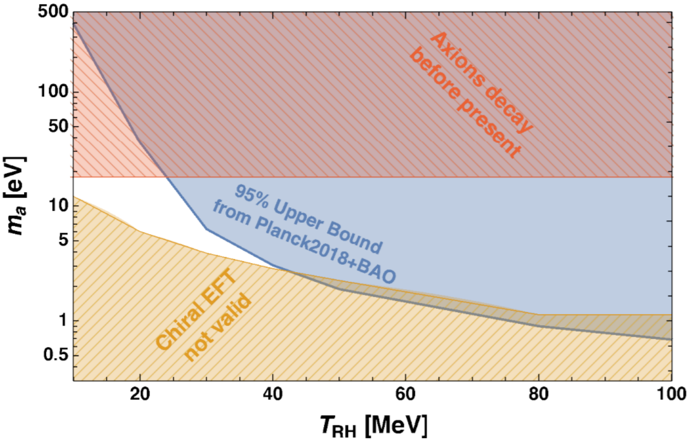
Axion Cold Dark Matter in a LTR scenario

The axion temperature is lowered: axions act as Cold Dark Matter in a LTR scenario



The relaxation of the bound

The cosmological axion bound is strongly relaxed in a LTR scenario



Conclusions

- The cosmological axion bound is relaxed in a LTR scenario
- Axions at the eV scale are probed by astrophysics (Supernova axions? Resonant solar conversions?)
- Also many experiments are planned to study this region (AMELIE, CUORE, WIMP-like experiments)

THANKS FOR YOUR ATTENTION!