STRONG BOUND ON
CANONICAL ULTRA-LIGHT AXION DARK MATTER
FROM THE LYMAN-ALPHA FOREST

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Simulations were computed for four different WDM mass scales. In the linear matter power spectrum induced by the term density relation and only FDM models considered here does not change significantly. We used in the range adapted to SDSS Lyman-\$^\alpha_0\$ flux measurements from Hu et al. (2000)

\[
\mathcal{T}(k) = \sqrt{\frac{P_{\text{ULADM}}(k)}{P_{\text{CDM}}(k)}}
\]

\[
\log(m_a[eV]) = \{ -22.3, -22.0, -21.4, -21.0, -20.4, -20.0, -19.4, -19.0, -18.7 \}
\]

\[
k_{1/2} \propto m_a^{9/4}
\]

Ly-alpha forest traces linear-order (mostly), high-redshift (\(z \sim 5\)), small-scale (< Mpc) density perturbations

\(~ 10^{-22} - 10^{-21} \text{ eV} \)

(ultra-light axions) may be preferred DM mass scale (axiverse/small-scale crisis)

Rogers & Peiris (2021ab, Phys. Rev. Lett., Phys. Rev. D); Armengaud et al. (2017)
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• Improved **physically-consistent astrophysical model** — wider range of reionisation histories

• **Emulator/active learning** to marginalise robustly astrophysical uncertainty (Rogers et al. 2019, JCAP)

• Exploit new data measuring smallest scales in density field — search for ULA DM cut-off from heavier axions
“Canonical” $10^{-22} - 10^{-21}$ eV ULA DM is strongly disfavoured by new bound.

Axion dark matter mass $[\text{log(eV)}]$:

-22 \rightarrow -21 \rightarrow -20 \rightarrow -19 \rightarrow -18

-22 \rightarrow \text{CMB/reionisation}

-20.7 \rightarrow \text{Sub-halos}

-20.7 \rightarrow \text{Ly-}\alpha\text{f (previous work)}

-19.6 \rightarrow \text{Ly-}\alpha\text{f (this work)}

Improve bound by $\sim$ order of magnitude

$m_a > 2 \times 10^{-20}$ eV

Rogers & Peiris (2021ab, Phys. Rev. Lett., Phys. Rev. D)