Cosmological effects of DM-γ scattering

Invisibles Workshop, 06/09/18, Karlsruhe
based on arXiv 1802.06589 & arXiv 1807.10034
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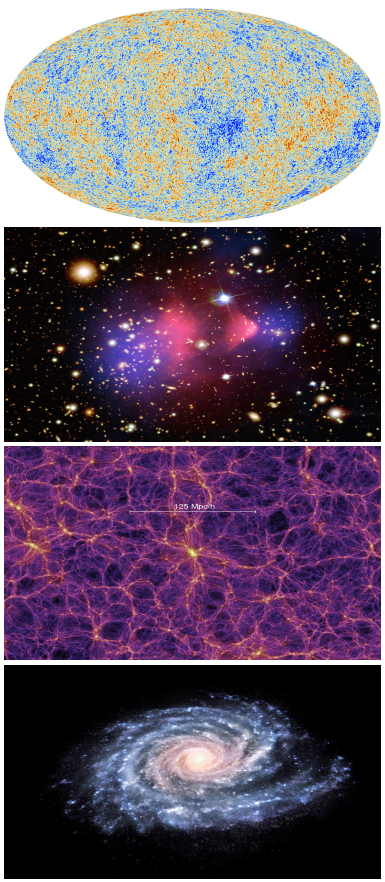
Being agnostic about DM properties

ΛCDM assumes DM is completely **collisionless** and has **zero velocity**. However, one can ask...



Cold-DM
But how cold?

- Warm dark matter
- Ultralight dark matter
- ...

C-**Dark**-M
But how dark?

- Self interacting DM
- DM-baryon scattering
- DM-ν scattering
- DM-γ scattering
- DM-DR scattering
- ...

CMB constraints on γ-DM scattering

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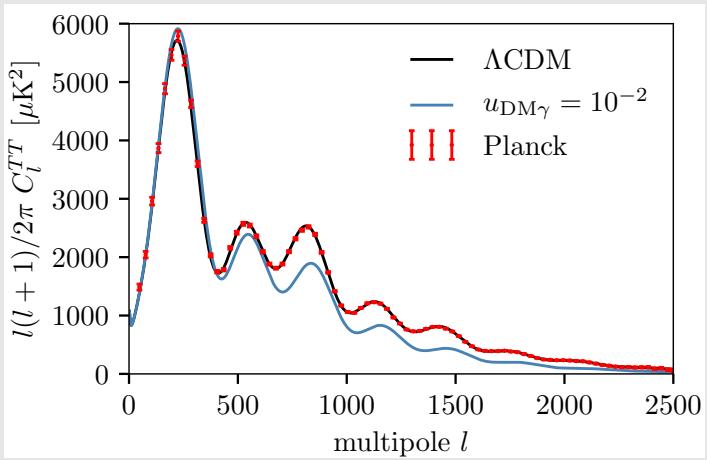

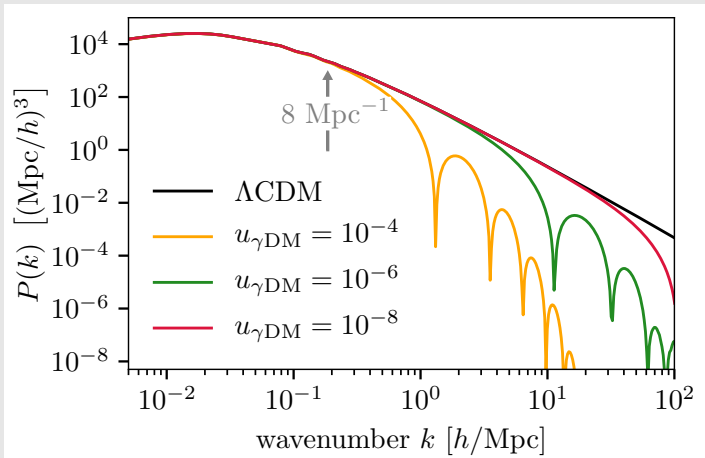

$$u_{\gamma\mathrm{DM}} = \frac{\sigma_{\gamma\mathrm{DM}}}{\sigma_{\mathrm{Th}}} \left(\frac{m_{\gamma\mathrm{DM}}}{100\ \mathrm{GeV}} \right)^{-1}$$

[Bœhm et al. (2001, 2004), Wilkinson et al. (2014)]

C-**Dark**-M
But how dark?

→ DM-ν scattering

→ DM-γ scattering

→ DM-DR scattering

→ ...

What have we improved?

- Accurate treatment of the tight coupling regime.
- Parameter constraints including Planck polarisation data.
- Inclusion of the DM sound speed.
- Extension to multi-component DM ("mixed DM").

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- Accurate treatment of the tight coupling regime.

  The impact is below the Planck sensitivity.

- Parameter constraints including Planck polarisation data.

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Constraints from Planck 2015

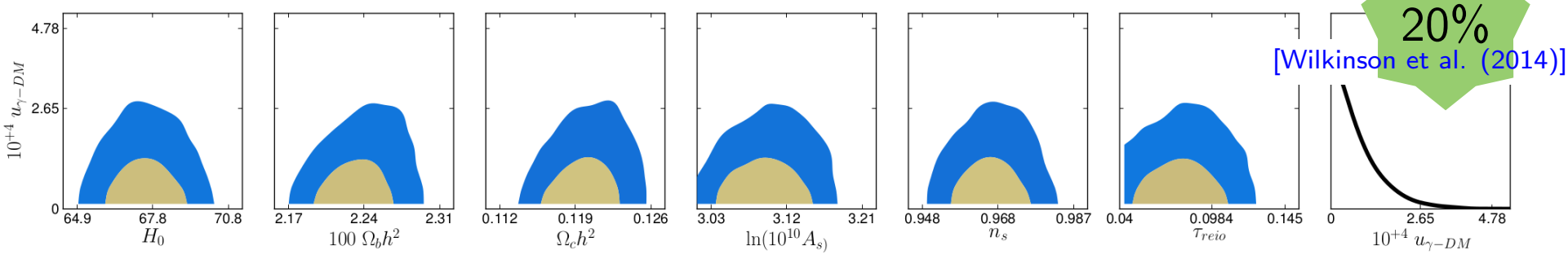
[arXiv 1802.0658]

→ Computation of CMB spectra with `CLASS` [Blas, Lesgourgues, Tram (2011)]

→ MCMC sampling with `MontePython` [Audren, Lesgourgues et al. (2012)]

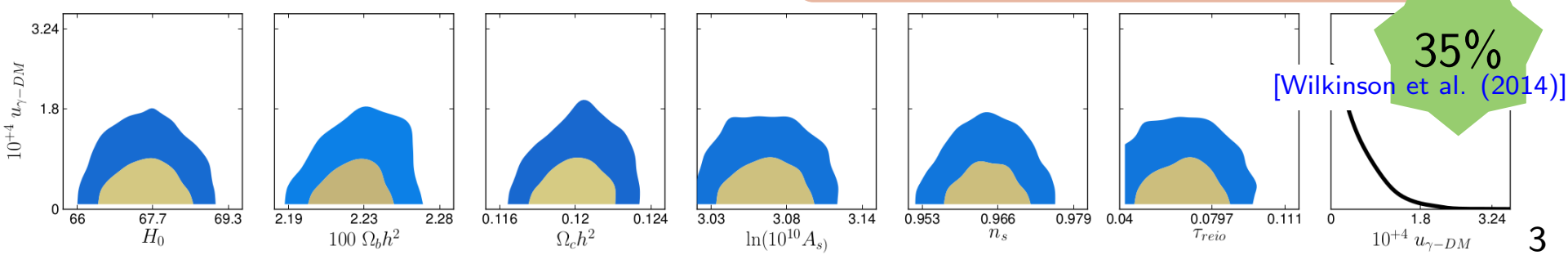
→ Parameter Space: 6 ΛCDM parameters + $u_{\gamma \mathrm{DM}}$

"Planck TT + lowTEB": $\sigma_{\gamma \mathrm{DM}} < 1.5 \times (m_{\mathrm{DM}}/\mathrm{GeV})\ \mathrm{fm}^2$



20% [Wilkinson et al. (2014)]

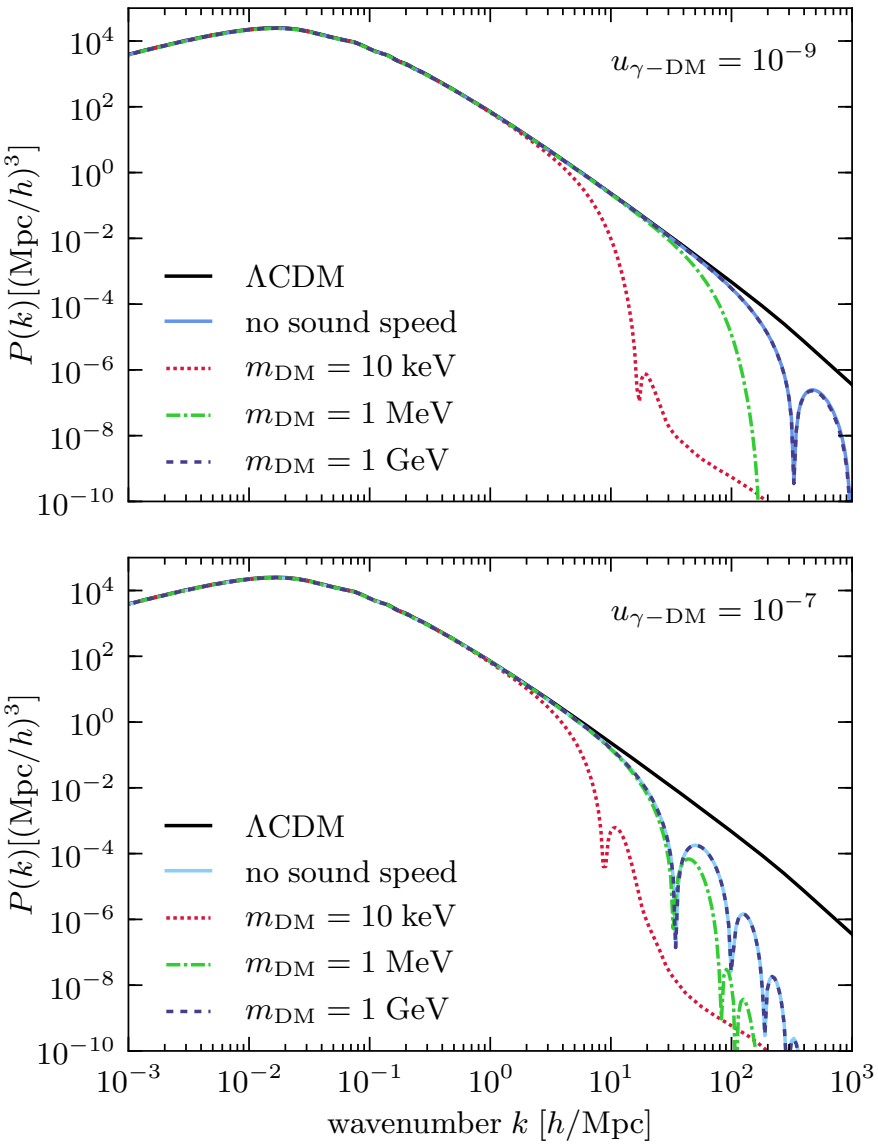
"Planck TTTEEE + lowTEB + lensing": $\sigma_{\gamma \mathrm{DM}} < 1.0 \times (m_{\mathrm{DM}}/\mathrm{GeV})\ \mathrm{fm}^2$



35% [Wilkinson et al. (2014)]

DM sound speed

[arXiv 1802.0658]



$$c^2_{\gamma\mathrm{DM}} = \frac{k_\mathrm{B}\, T_{\gamma\mathrm{DM}}}{m_{\gamma\mathrm{DM}}} \left[1 - \frac{1}{3}\frac{\partial \ln T_{\gamma\mathrm{DM}}}{\partial \ln a}\right]$$

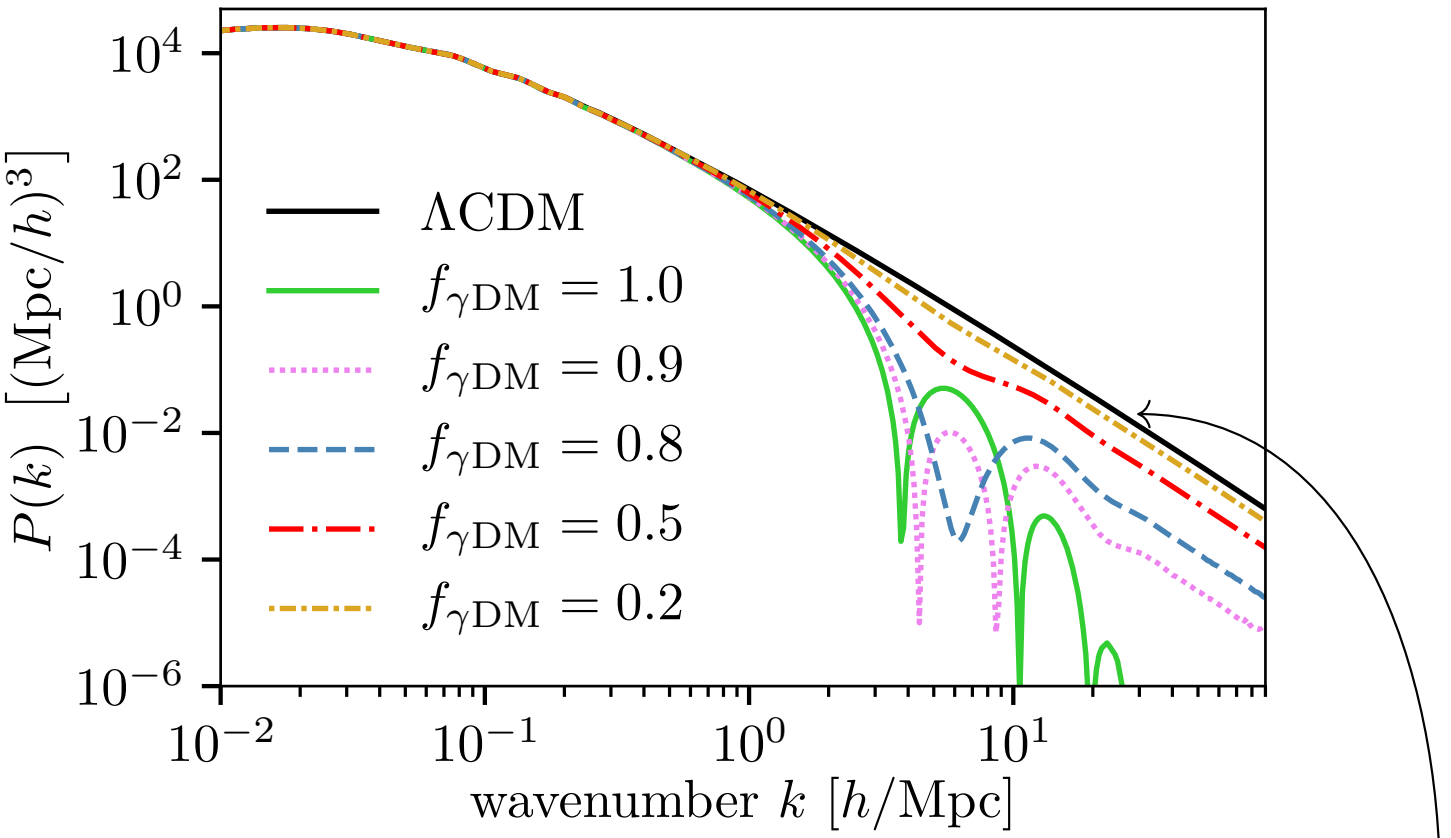
→ **Effect on the CMB:**
Irrelevant for $m_{\gamma\mathrm{DM}} \geq 10\,\mathrm{keV}$.

→ **Effect on $\mathbf{P(k)}$:**
Can be significant if $m_{\gamma\mathrm{DM}} \leq 1\,\mathrm{GeV}$.

Mixed DM: matter power spectrum

[arXiv 1807.10034]

DM is composed of an interacting (γDM) and a collissionless (CDM) component $\Rightarrow$ $f_{\gamma\mathrm{DM}} = \Omega_{\gamma\mathrm{DM}}/(\Omega_{\gamma\mathrm{DM}} + \Omega_{\mathrm{CDM}})$.



Small $f_{\gamma\mathrm{DM}}$ can have a similar effect as massive neutrinos.