Dark Matter-Dark Radiation Interaction

CMB-S4 Collaboration Meeting, Snowmass Session

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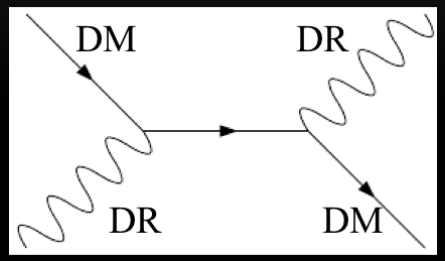
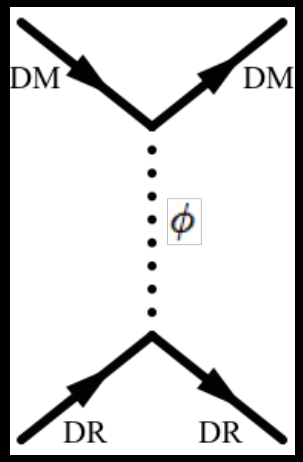
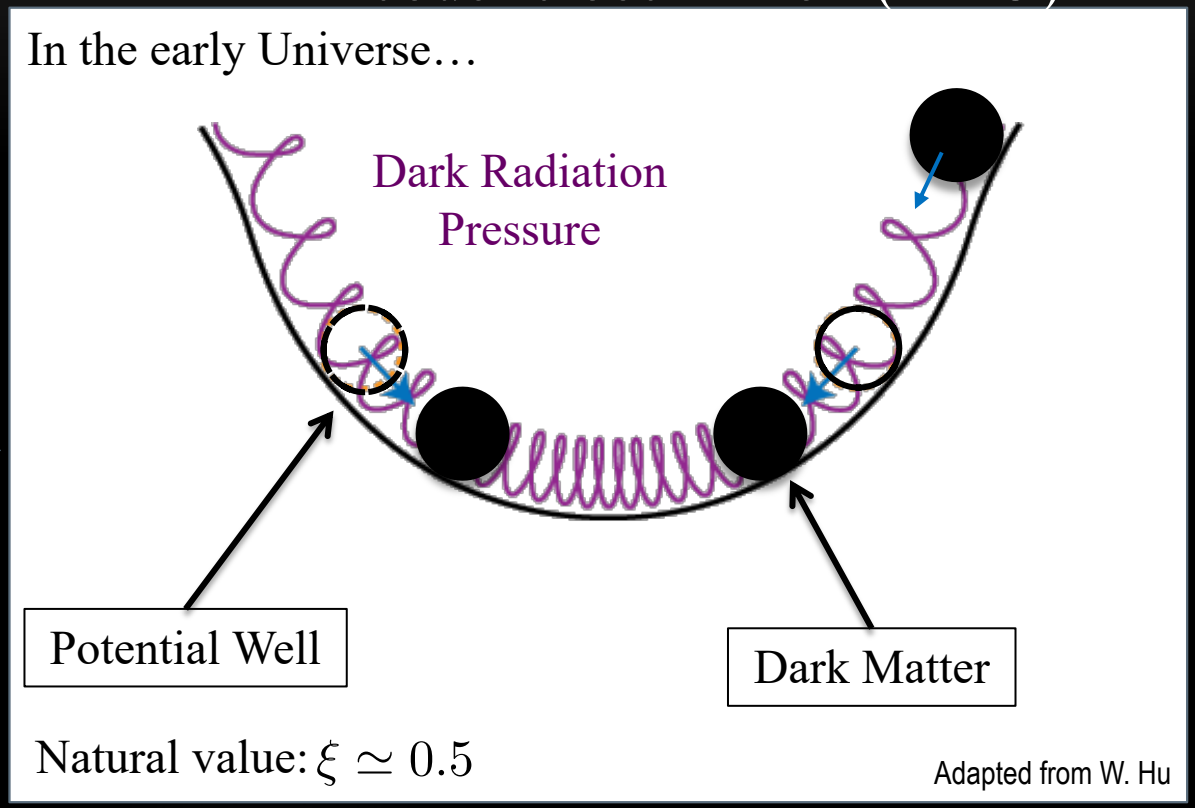
Phenomenology of dark matter-dark radiation (DR) interaction





Cyr-Racine & Sigurdson (2013)

Dark acoustic oscillation (DAO)

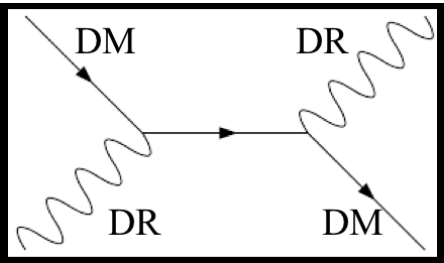


$$\xi \equiv \left(T_D / T_{\rm CMB}\right)\big|_{z=0}$$

Coupling dark matter to light relativistic species

- Example 1: Dark matter interacting with a massless photon.

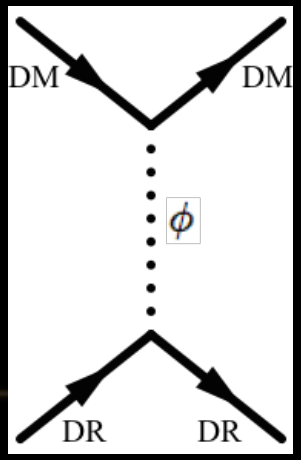
$$\mathcal{L}_{\rm int} = -(D^\mu \chi)^\dagger D_\mu \chi - m_\chi^2 \chi^\dagger \chi, \qquad \text{where} \qquad D_\mu = \partial_\mu - i g_\chi \tilde{A}_\mu.$$



- Example 2: Dark matter interacting with a massless neutrino via a massive mediator.

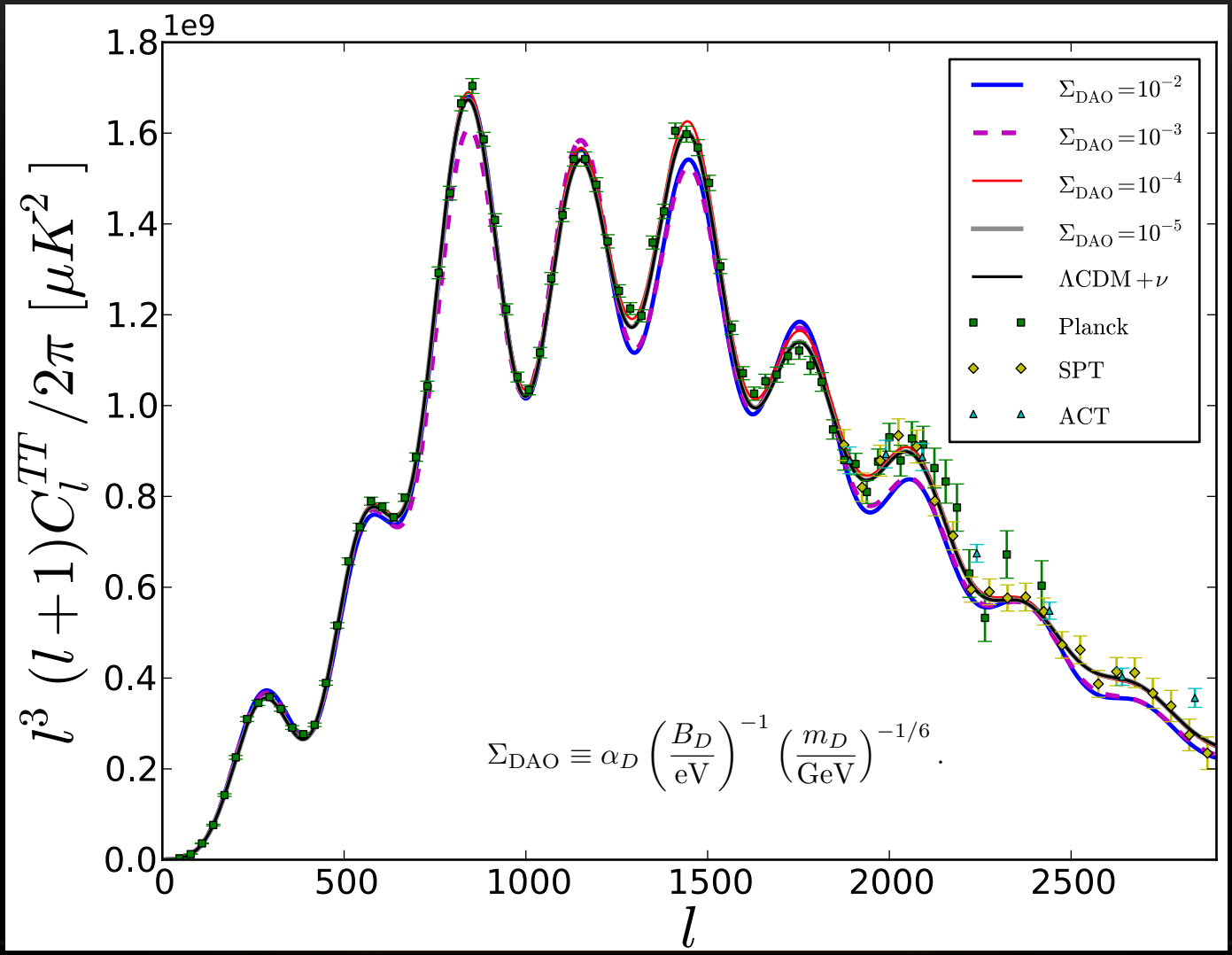
$$\mathcal{L}_{\rm int} = -g_\chi \phi_\mu \bar{\chi} \gamma^\mu \chi - \frac{1}{2} g_\nu \phi_\mu \bar{\nu}_{\rm s} \gamma^\mu \nu_{\rm s} - \frac{1}{2} m_\phi^2 \phi_\mu \phi^\mu - \frac{1}{2} m_\chi \bar{\chi} \chi$$

…and many more!



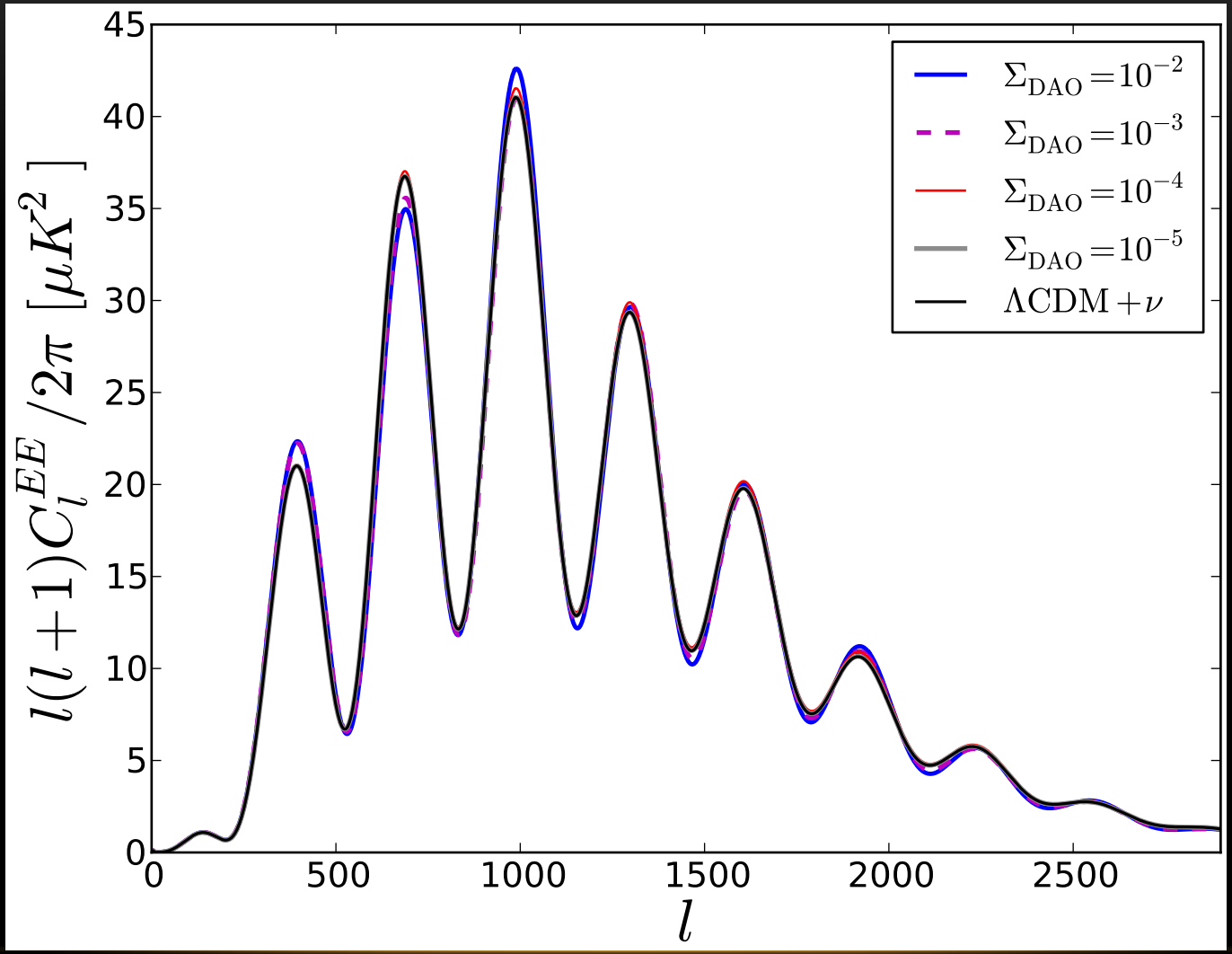
Hofmann et al. 2001; Chen et al. 2001; Bœhm et al. 2002; Green et al. 2004; Bertschinger 2006; Bringmann & Hofmann 2007; van den Aarssen et al. 2012 and many more.

Impact on CMB power spectra: TT



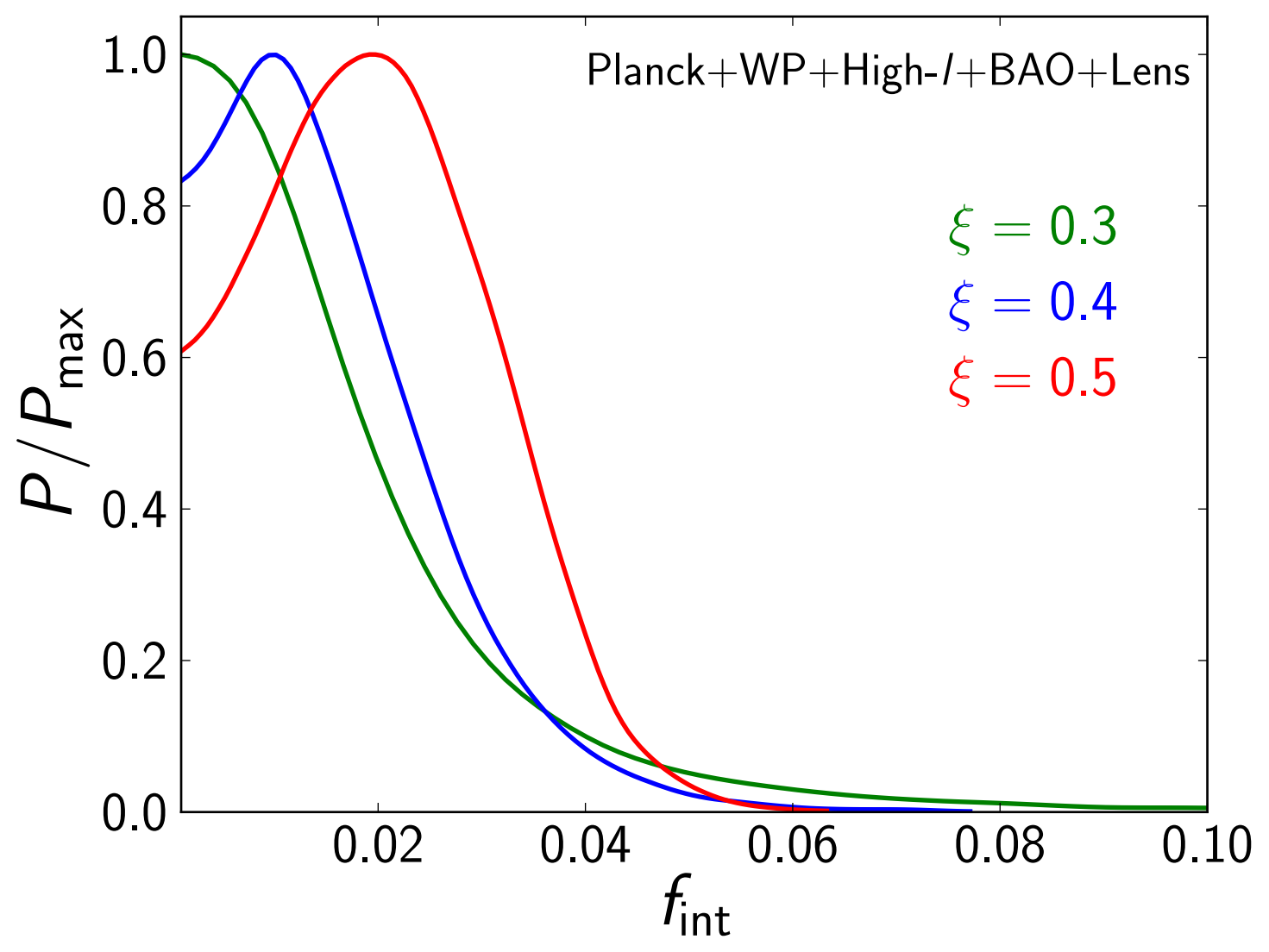
Cyr-Racine et al. (2013)

Impact on CMB power spectra: EE



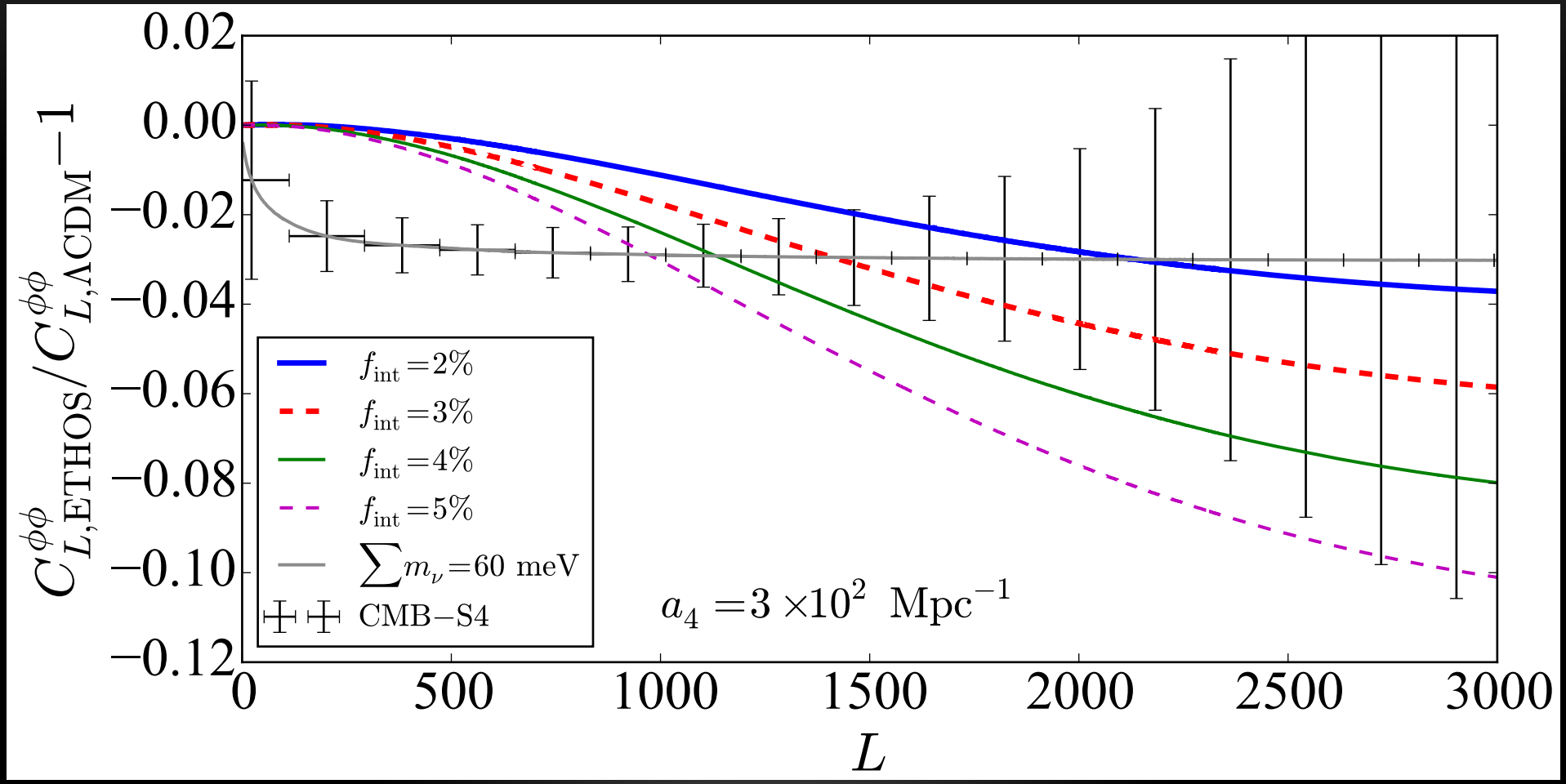
Cyr-Racine et al. (2013)

Sensitivity of Planck data to DM-DR interaction



Cyr-Racine et al. (2013), see also Archidiacono et al. (2019)

Prospects for DM-DR interaction with CMB-S4



CMB-S4 Science Book

Conclusions

- DM-DR collisions at early times leave distinct imprints on the primary CMB and through CMB lensing.
- CMB already constraints $f_{\rm int} < 5\%$ for DM-DR interaction of SM electromagnetic strength.
- Future constraints on DM-DR interaction will be lensing dominated.
- CMB-S4 is likely to push the allowed fraction to sub-percent level, or to an actual detection.

Thank you!