Searching for Dark Matter Interactions with ACT, SPT and DES

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Work with Neal Weiner (NYU)
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TeVPA 2024

Outline

- Overview of S8 and recent developments on the tension.
- Discuss “model dependence” of S8 tension.
- Model of dark matter interaction: theory, data and analysis.
- Results and conclusions.

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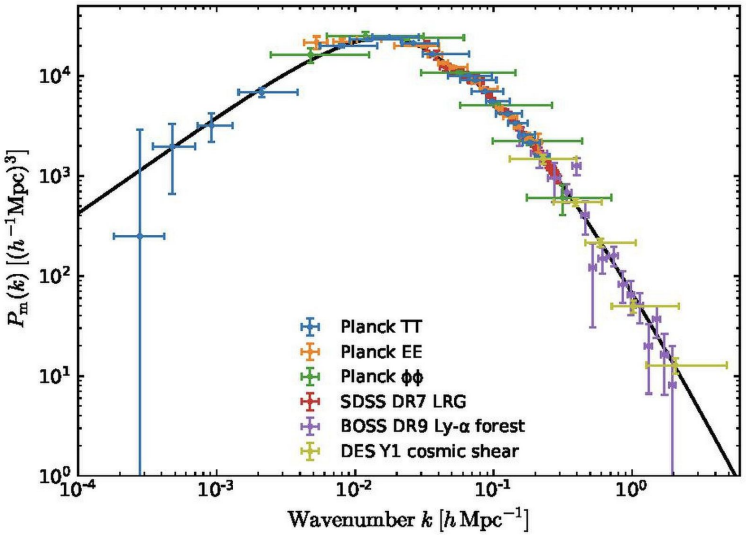
Main Points:

- S8 tension is a **ΛCDM** inferred tension.
- CMB Lensing can be consistent with both CDM and IDM scenarios.

The S8 Tension: Status Overview

- σ8: Amplitude of the Linear Matter Power Spectrum at k=h/(8 Mpc).
- $S8=\sigma8 \times (\Omega_m/0.3)^{0.5}$



Planck 2018

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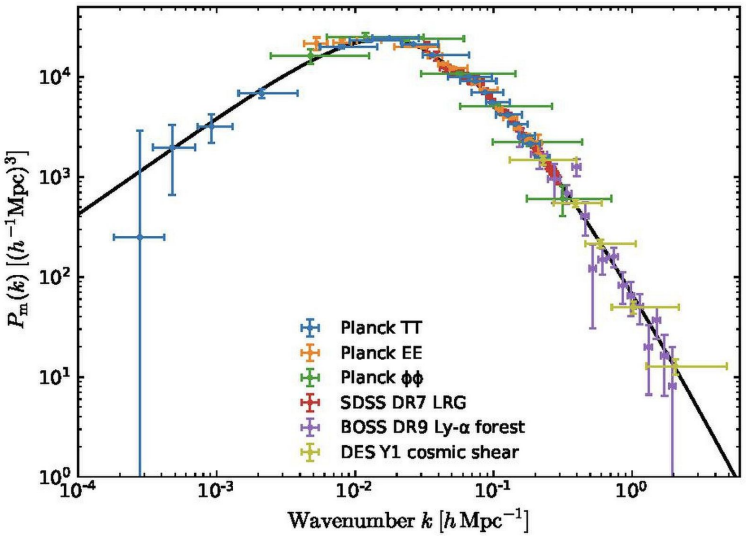

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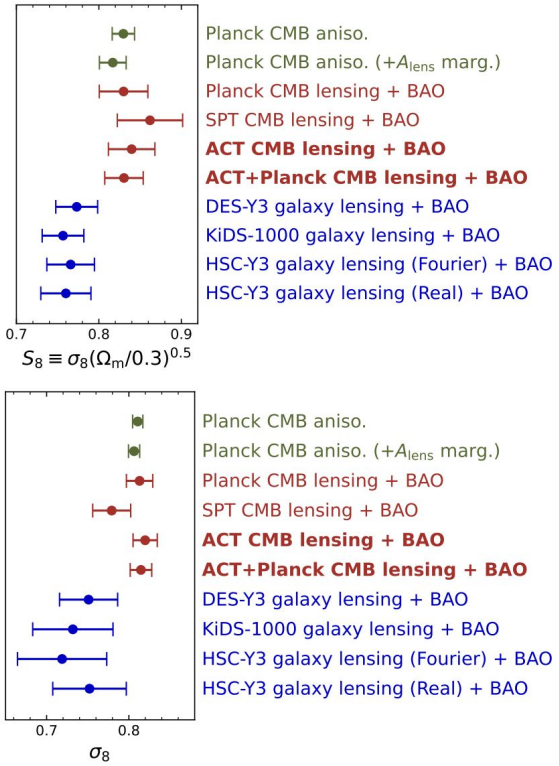

Madhavacheril et al. 2024

S8 Tension: Measurement or Model?

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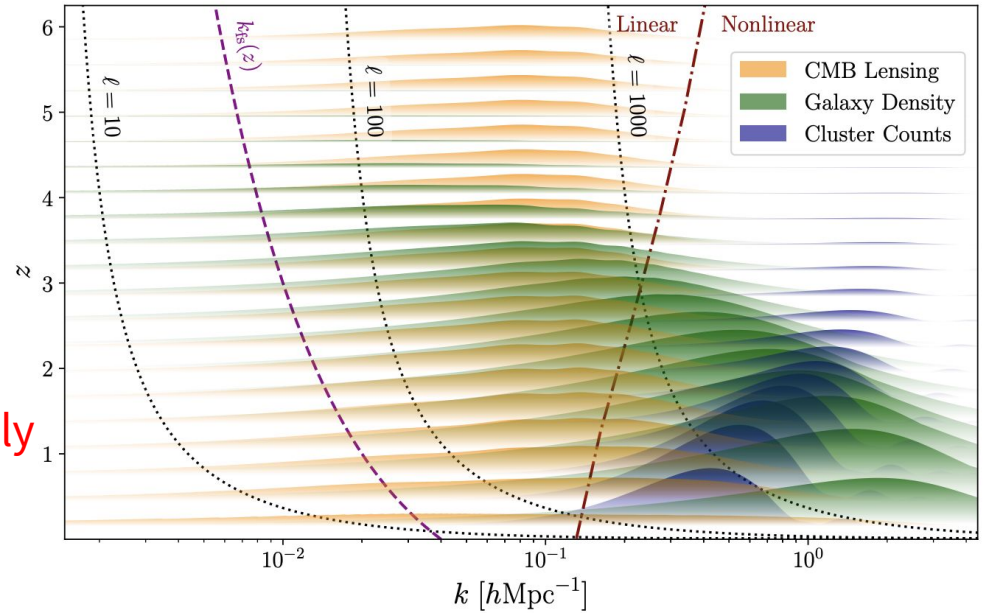

Gerbino et al. 2022

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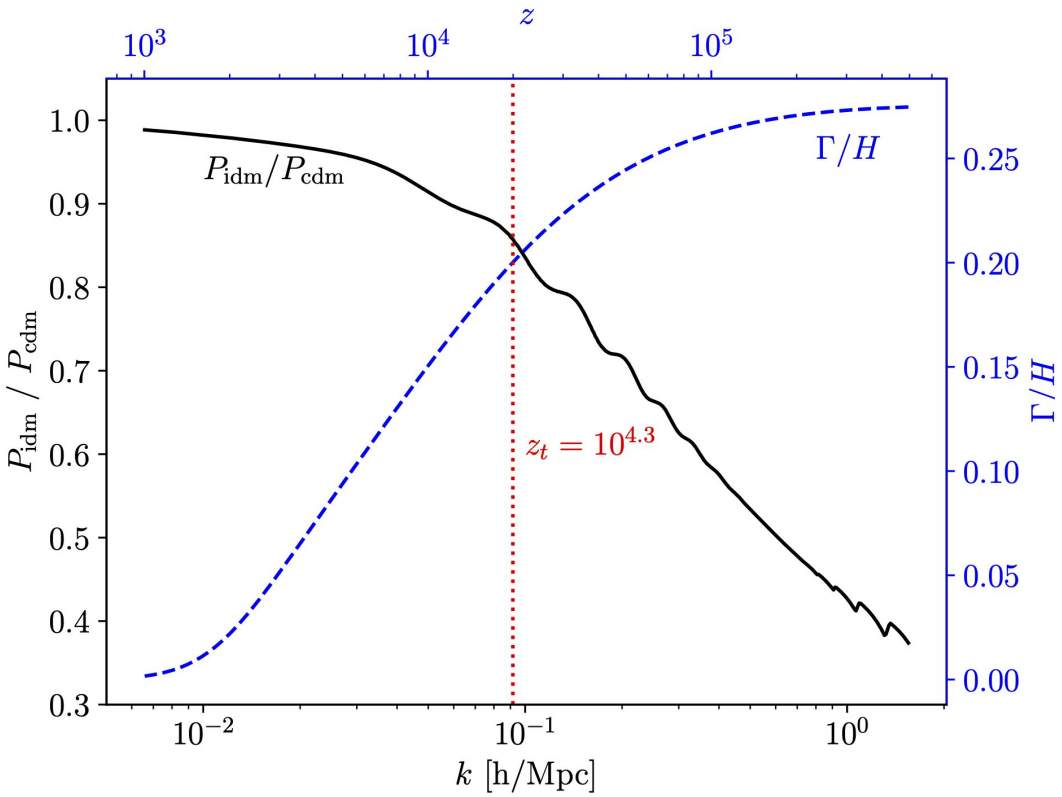
So if we modify ΛCDM, what is the data telling us?

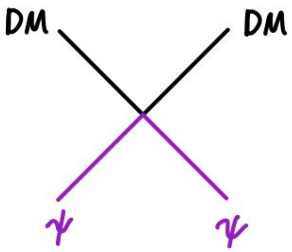
WZDR+: “Gentle” Dark Matter Interaction



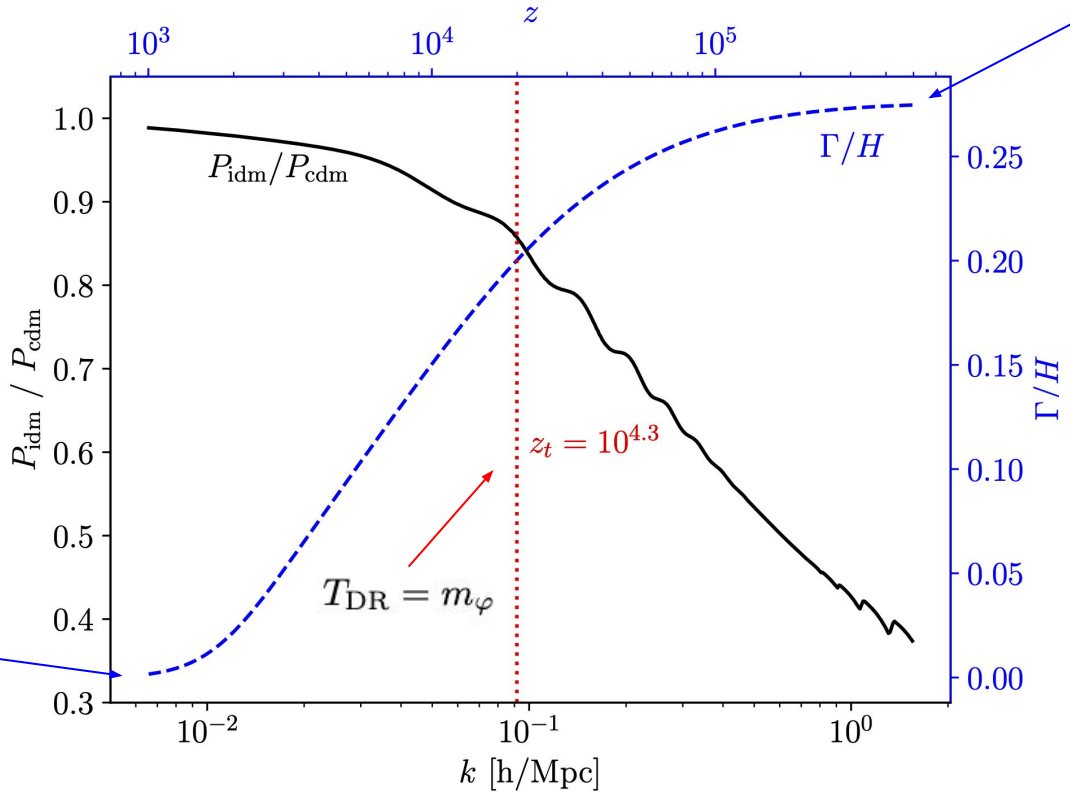
ZZ & Weiner 2024

WZDR+: "Gentle" Dark Matter Interaction

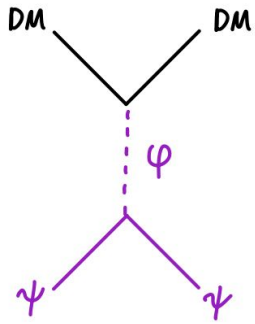
4-Fermi Operators



CDM-like at late time



Interacting DM at early time



Yukawa Operators

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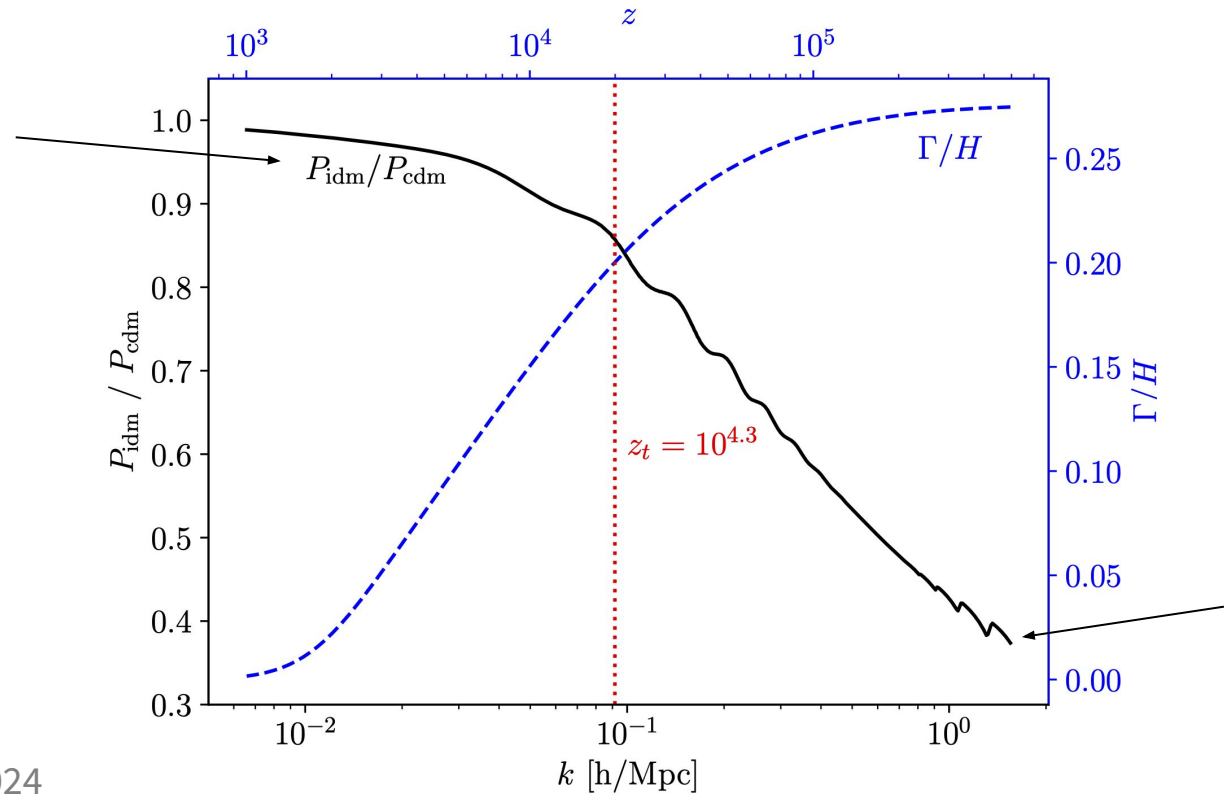
WZDR+: “Gentle” Dark Matter Interaction

Late horizon crossing, inefficient scattering, no suppression.



Early horizon crossing, clustering suppressed.

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WZDR+ with ACT, SPT and DES

We perform MCMC (CLASS + MontePython) Sampling with:

1. **Base**: Planck18TTTEEE+BAO+Planck Lensing+**ACTDR6 CMB Lensing**+Pantheon
2. **ACT**: ACTDR4 TTTEEE anisotropy
3. **SPT**: SPT-3G TTTEEE anisotopy

And in addition we consider

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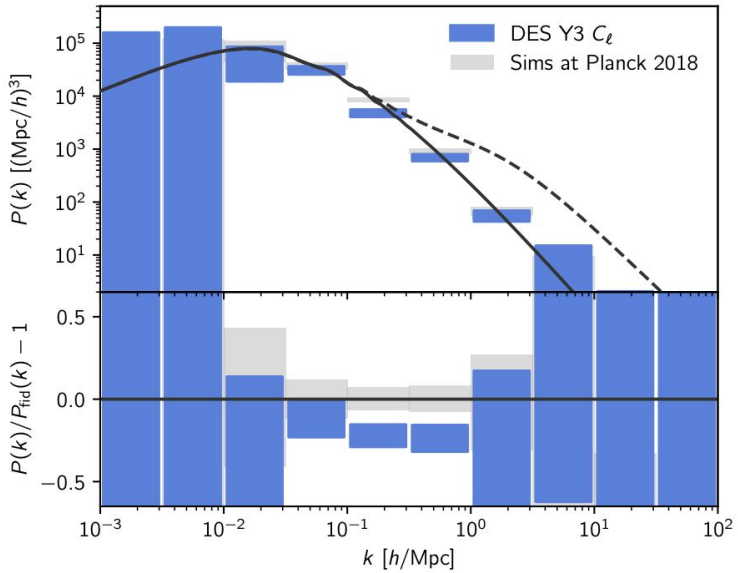
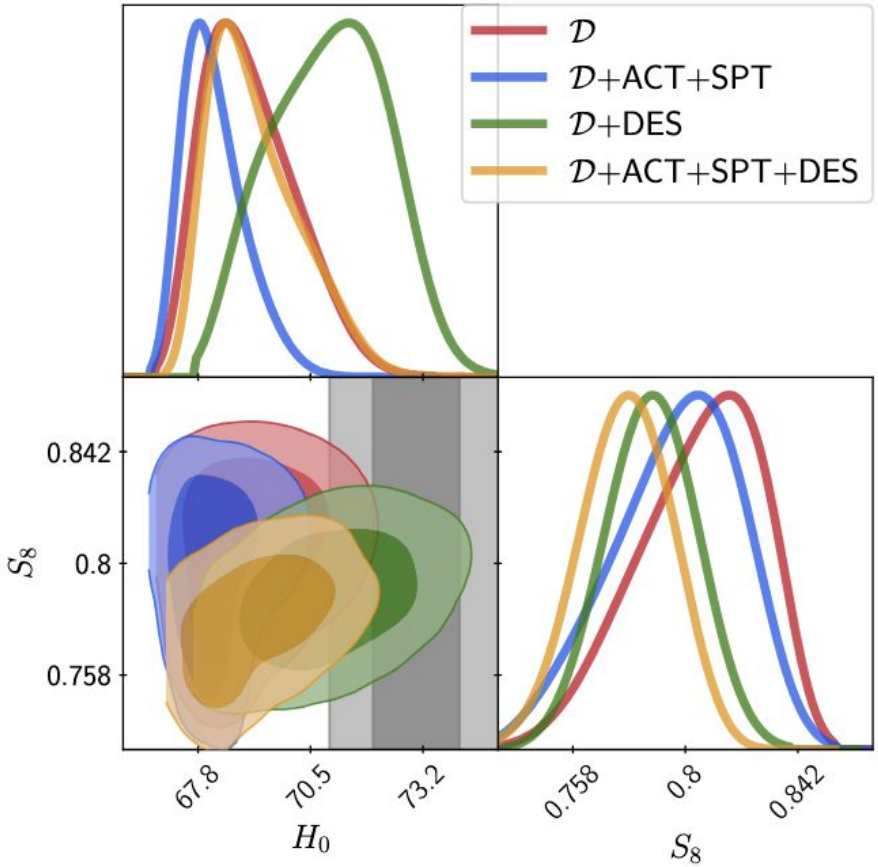
Instead of an S8 prior we use:



Doux et al. 2022

Results



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Results

Quantifying goodness of fit:

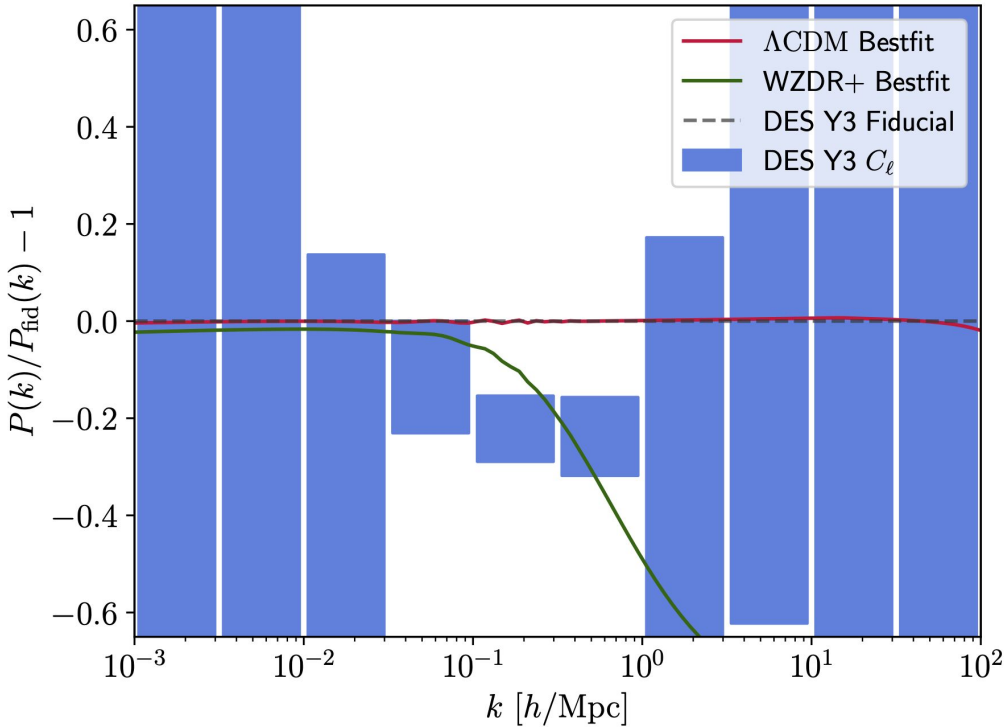
$$\Delta\mathrm{AIC} = \chi^2_{\mathrm{WZDR+}} - \chi^2_{\Lambda\mathrm{CDM}} + 2 \times N_{\mathrm{extra}}$$

- DES-Excluded fit: **ΔAIC=+2.08**
- DES-Included fit: **ΔAIC=-16.58**
- WZDR+ fits the full data set (CMB+LSS + ACT Lensing + DES) significantly better than ΛCDM.

Conclusions & Outlook

- The S8 tension is not a tension between early and late time measurements, but rather the inferred value from fits **assuming ΛCDM cosmology**.
- Modifying the transfer function can result in vastly different conclusions about S8 even when fitting to the same dataset.
- A new physics model like WZDR+ can accommodate all available data that were thought to conflict each other on S8.
- New physics solutions to S8 are still possible!

Additional Plots



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