Title: TBD

Date: Jan 25, 2018 11:00 AM

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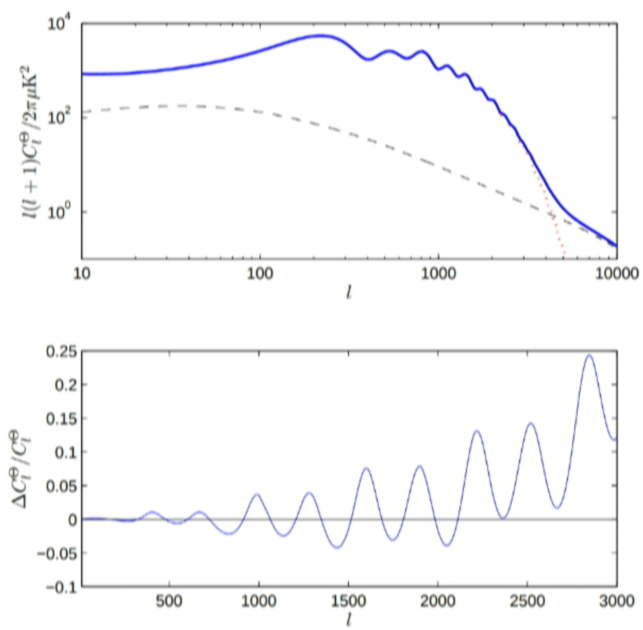
Abstract:

Internal Delensing of CMB Acoustic Peaks

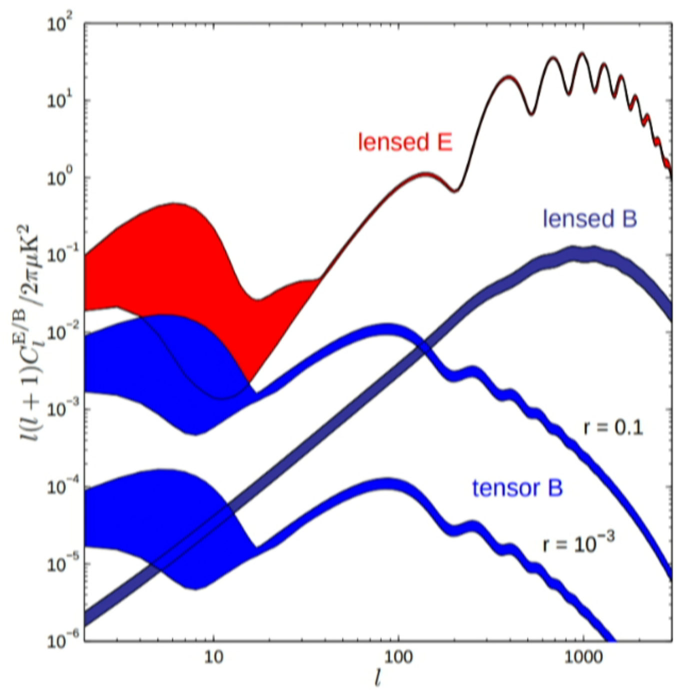
Mathew Madhavacheril
(with Neelima Sehgal, Blake Sherwin, Alexander van Engelen)

Lensing modifies CMB power

- Lensing shifts power around
  - Smears acoustic peaks
  - Converts E-modes to B-modes
- Lensing B-modes obscure gravitational wave signature



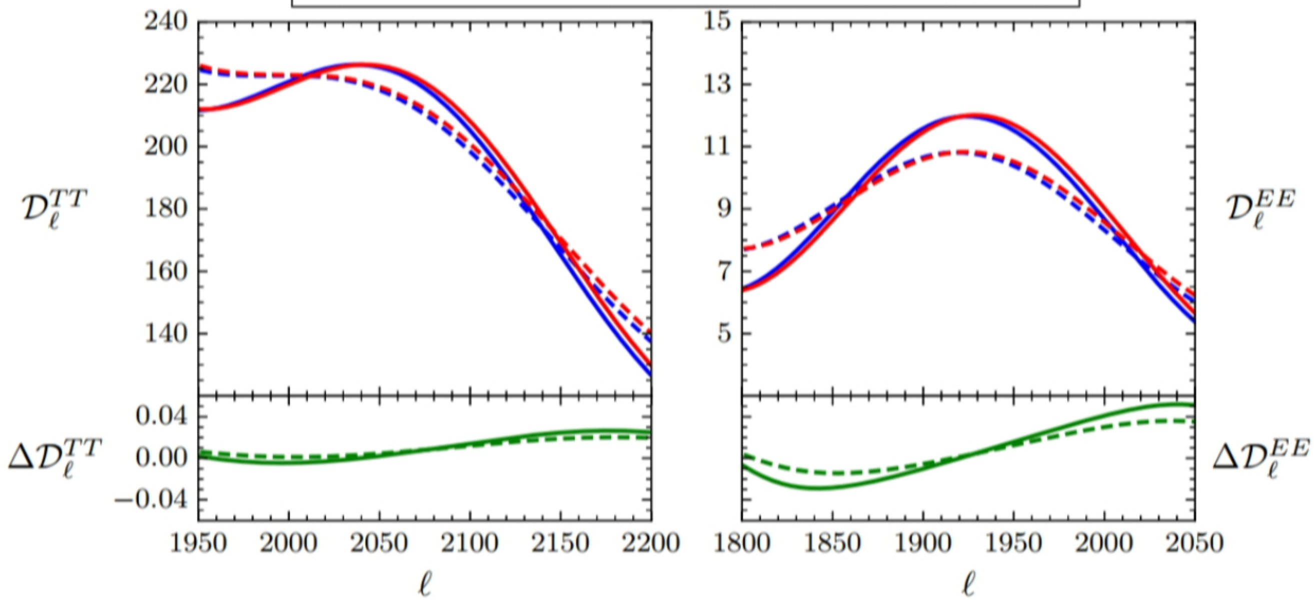
Lewis, Challinor 2006



Lensing modifies CMB power

- Lensing shifts power around
    - Smears acoustic peaks
- Acoustic peak sharpness important: ~ 30% improvement in constraint on N_eff if lensing removed, much more if Yp free
- Covariance between 2-pt and 4-pt reduced

Solid: Unlensed spectra N_eff = 2.046 vs 3.046
Dashed: Lensed spectra



Baumann, Green, Meyers, Wallisch 2016

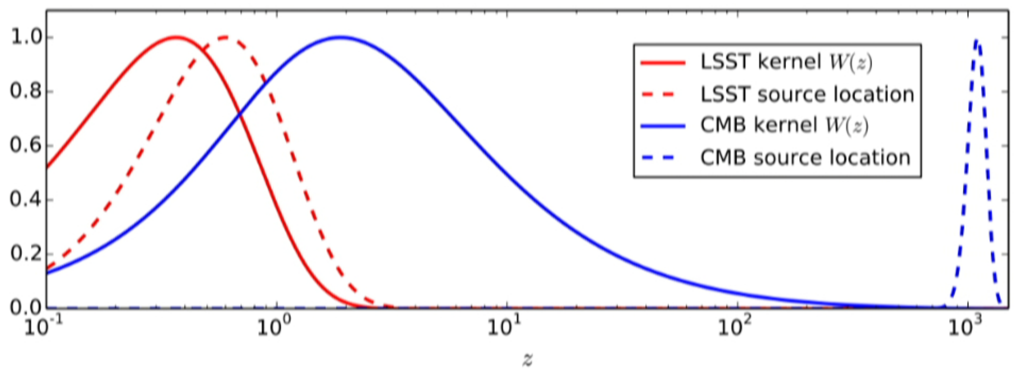
Delensing with a template

$$T^{\mathrm{lensed}}(\hat{\mathbf{n}}) = T^{\mathrm{unlensed}}(\hat{\mathbf{n}} + \nabla\phi)$$

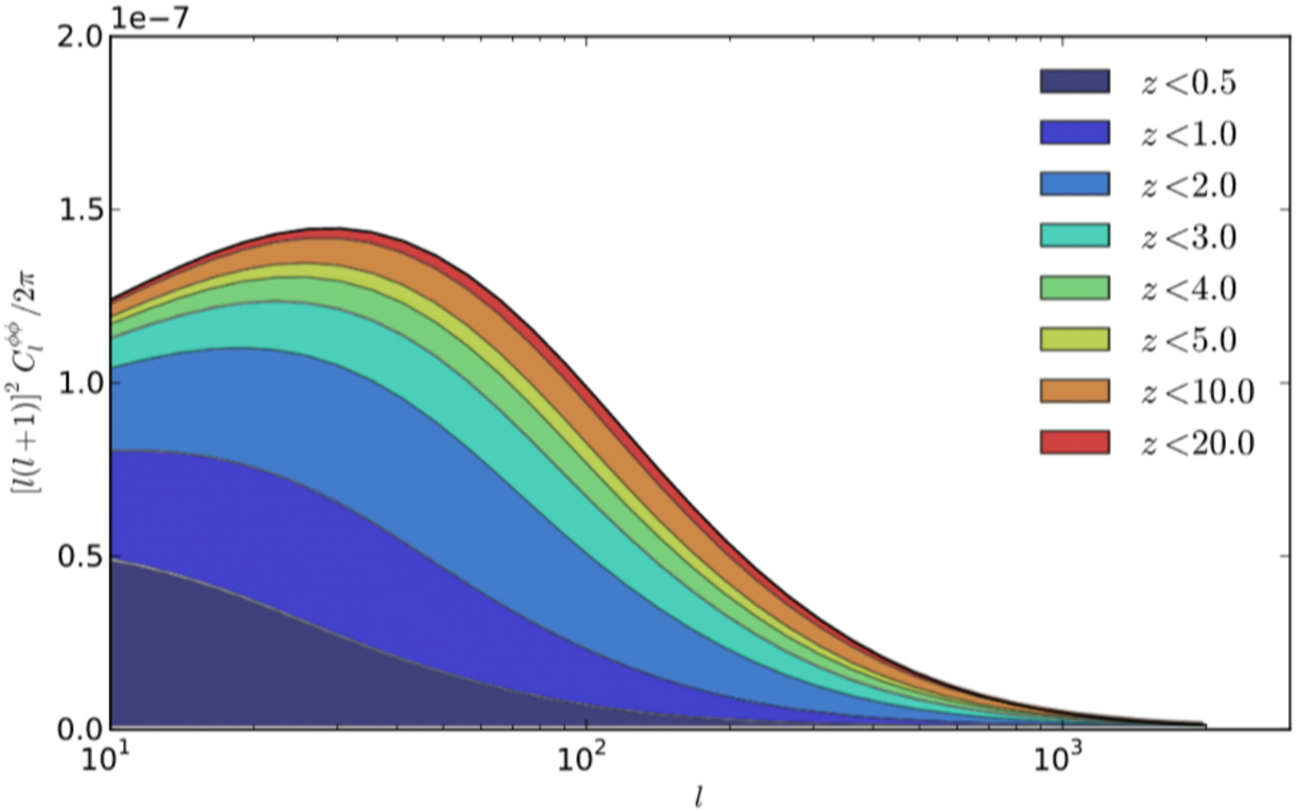
$$T^{\mathrm{delensed}}(\hat{\mathbf{n}}) = T^{\mathrm{lensed}}(\hat{\mathbf{n}} - \nabla\hat{\phi})$$

External tracers like optical shear or CIB:
high S/N now, but don't have all the lensing

Larsen et. al. 2016
Manzotti et. al. 2017



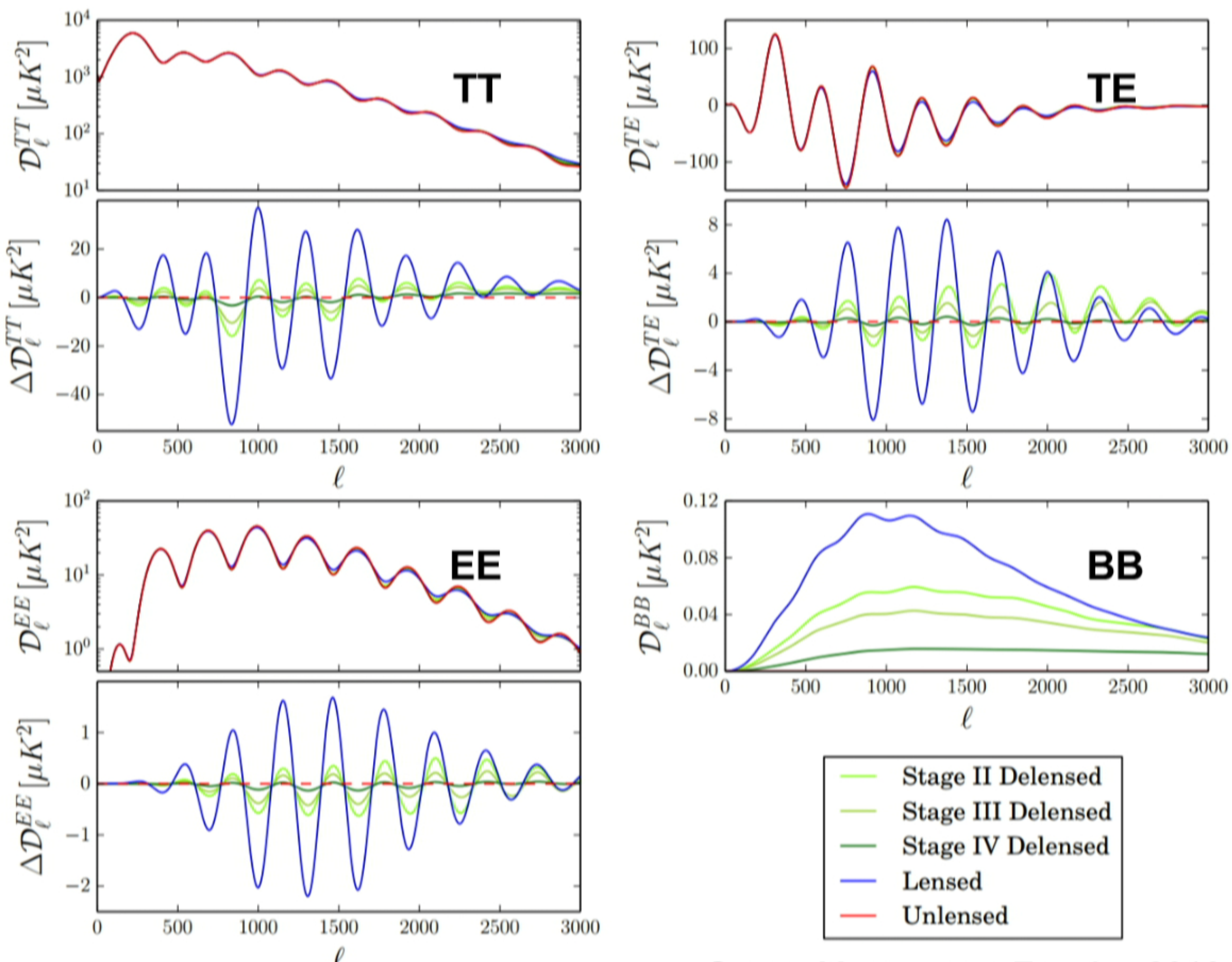
Non-negligible high-z contribution



30% power from z>5

Credit: Duncan Hanson?

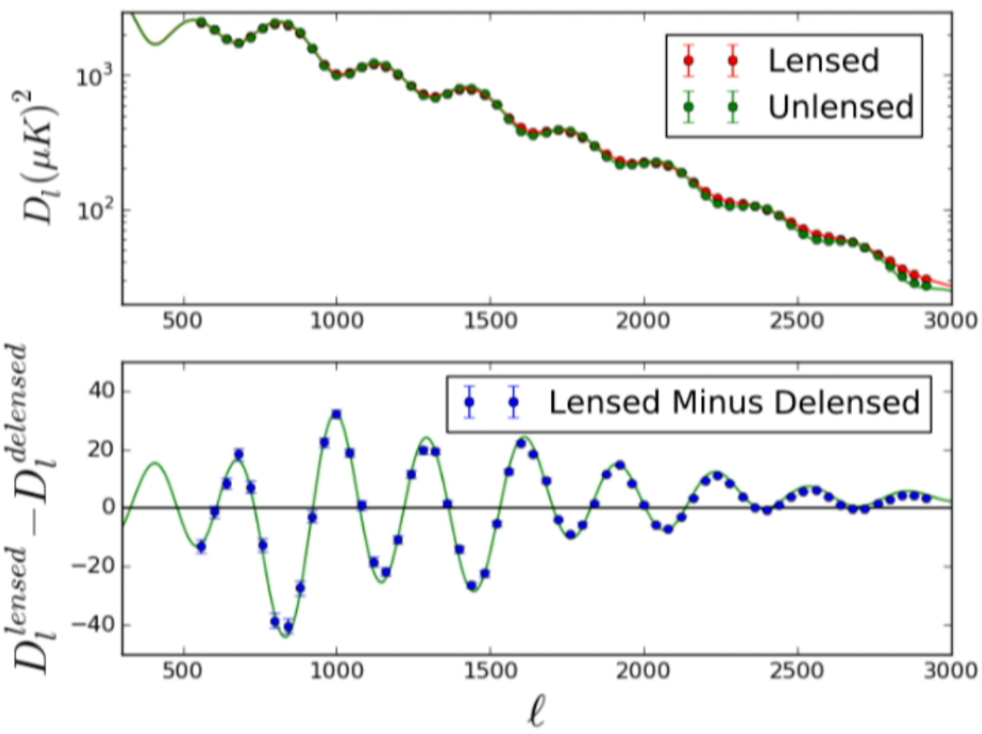
Internal delensing with future surveys



Green, Meyers, van Engelen 2016

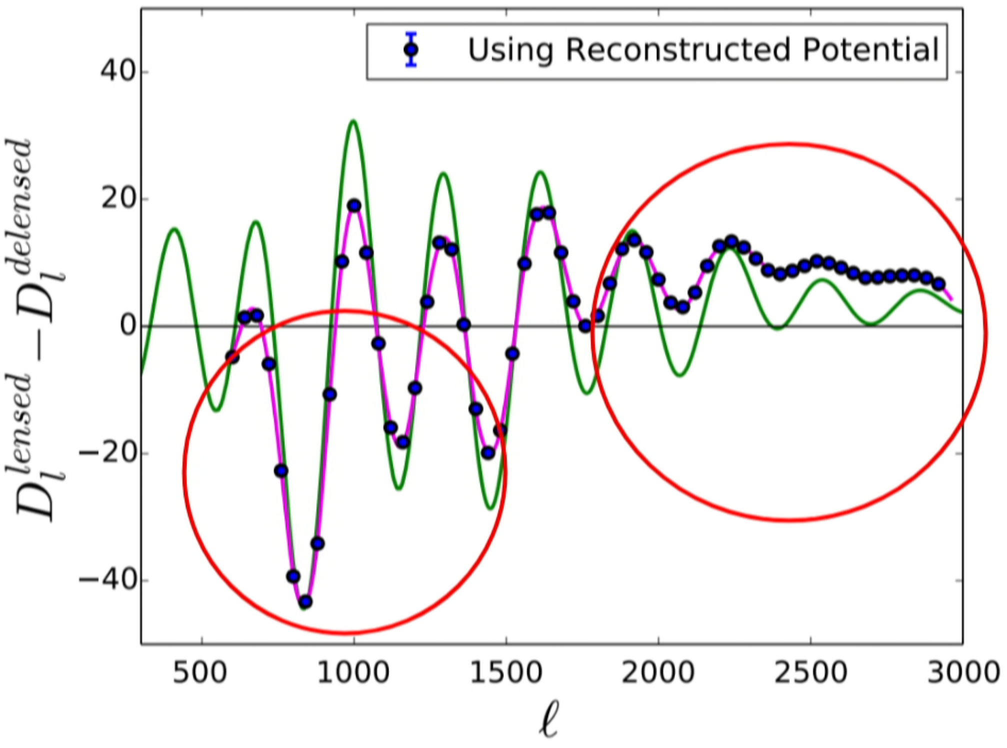
Demonstration attempt with a delensing pipeline

Sehgal, **MM**, Sherwin, van Engelen 2016



Delens with reconstruction

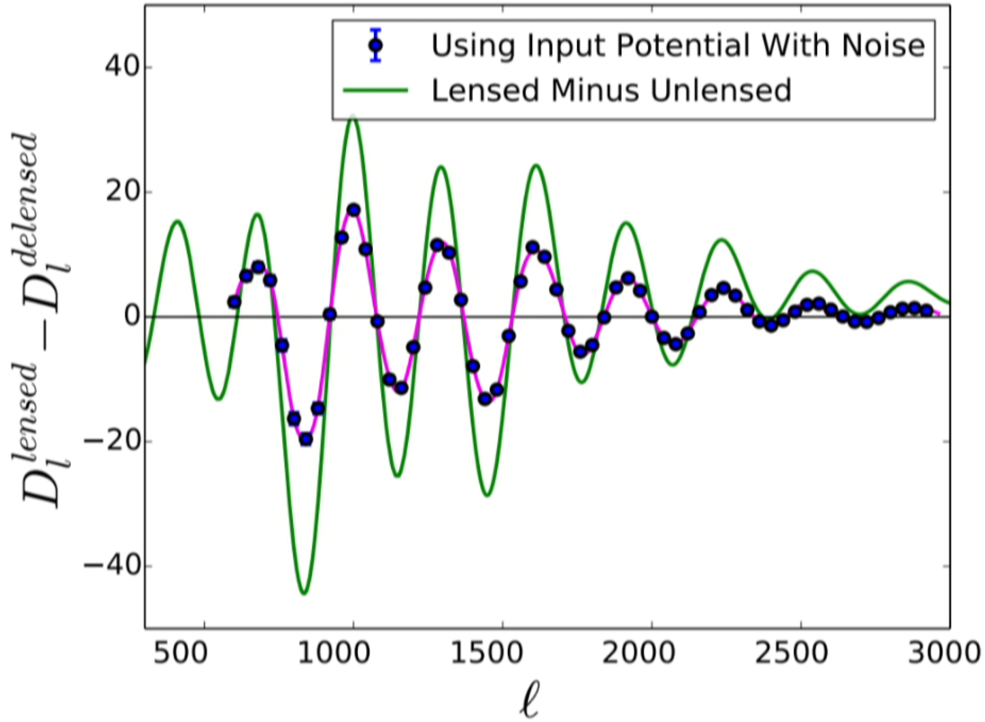
Sehgal, **MM**, Sherwin, van Engelen 2016



Test: Gaussian uncorrelated noise

Imperfect delensing because Wiener filtering out noisy modes

Sehgal, **MM**, Sherwin, van Engelen 2016



Origin of delensing bias

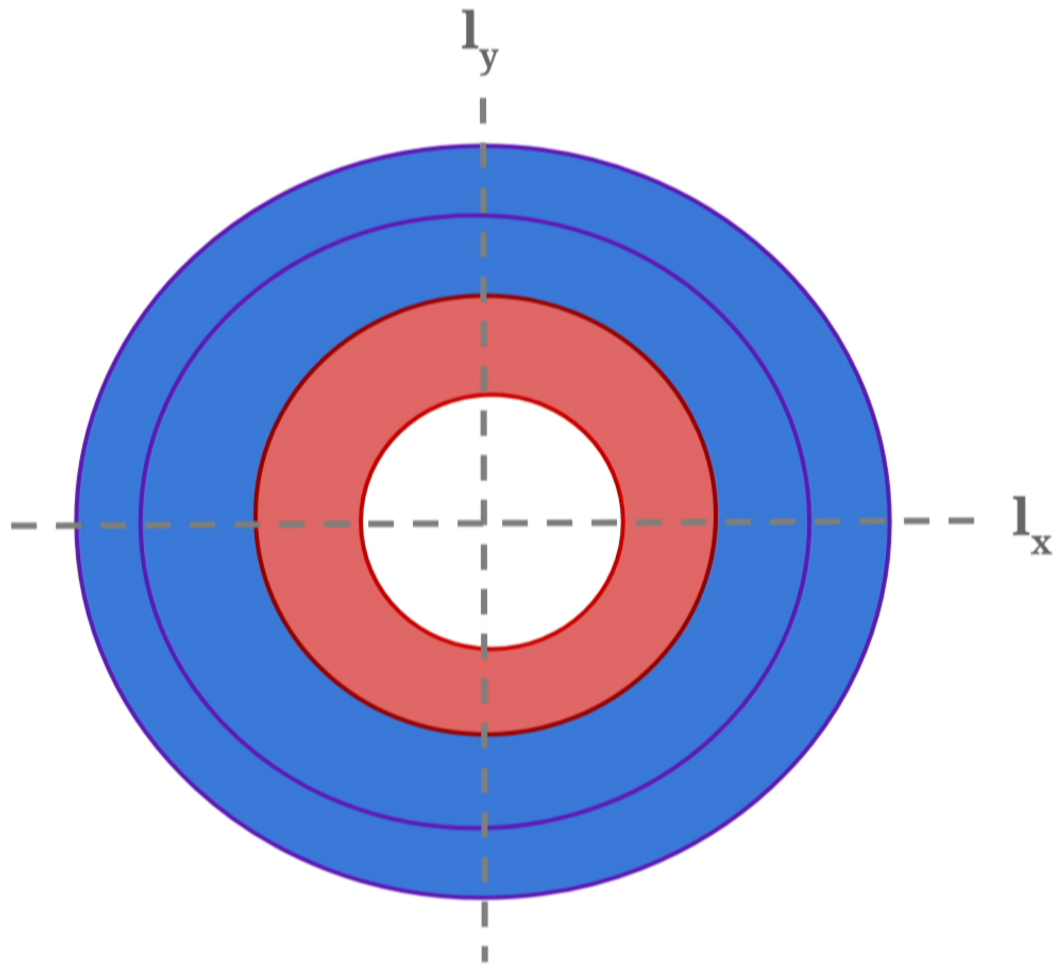
Plug in to delens equation. Calculate power.

$$\langle T^{\rm delensed}(\mathbf{l}_a)T^{\rm delensed}(\mathbf{l}_b)\rangle \supset \langle T(\mathbf{l}_a)T(\mathbf{l}_b)\rangle + 2\int \frac{d^2\mathbf{l}'}{(2\pi)^2}\mathbf{l}'\cdot(\mathbf{l}_b-\mathbf{l}')A_{TT}(\mathbf{l}')\int \frac{d^2\mathbf{l}_1}{(2\pi)^2}F^{TT}(\mathbf{l}_1,\mathbf{l}'-\mathbf{l}_1) \times\langle T(\mathbf{l}_a)T(\mathbf{l}_b-\mathbf{l}')T(\mathbf{l}_1)T(\mathbf{l}'-\mathbf{l}_1)\rangle$$

Power difference

$$C_l^{\rm lensed} - C_l^{\rm delensed} \supset 4\int \frac{d^2\mathbf{l}'}{(2\pi)^2}\mathbf{l}'\cdot(\mathbf{l}'+\mathbf{l})A_{TT}(\mathbf{l}') \times F^{TT}(-\mathbf{l},\mathbf{l}'+\mathbf{l})C_l C_{|\mathbf{l}+\mathbf{l}'|}.$$

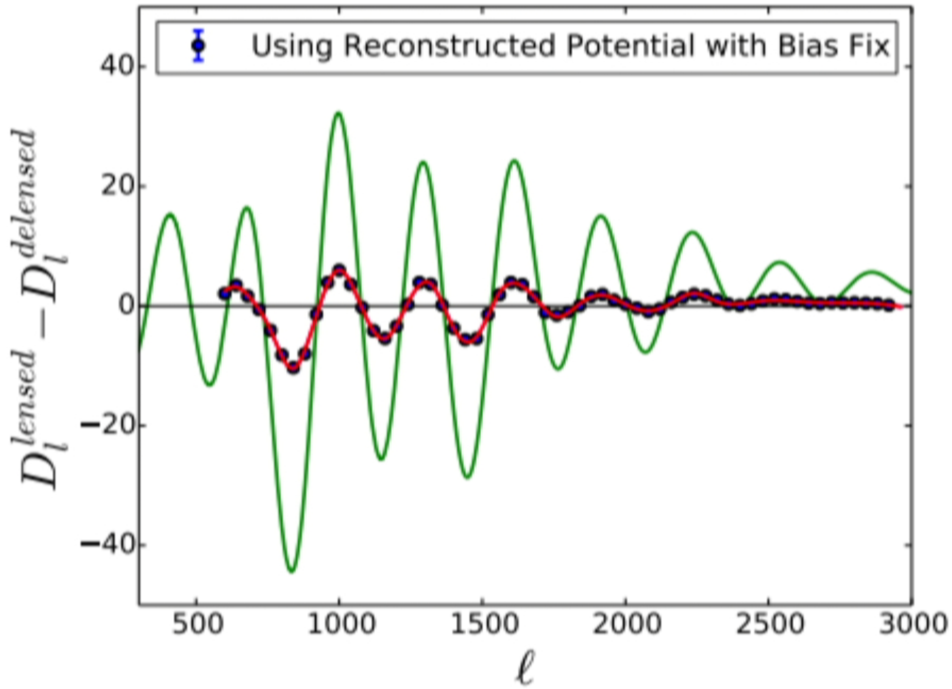
A solution



A solution

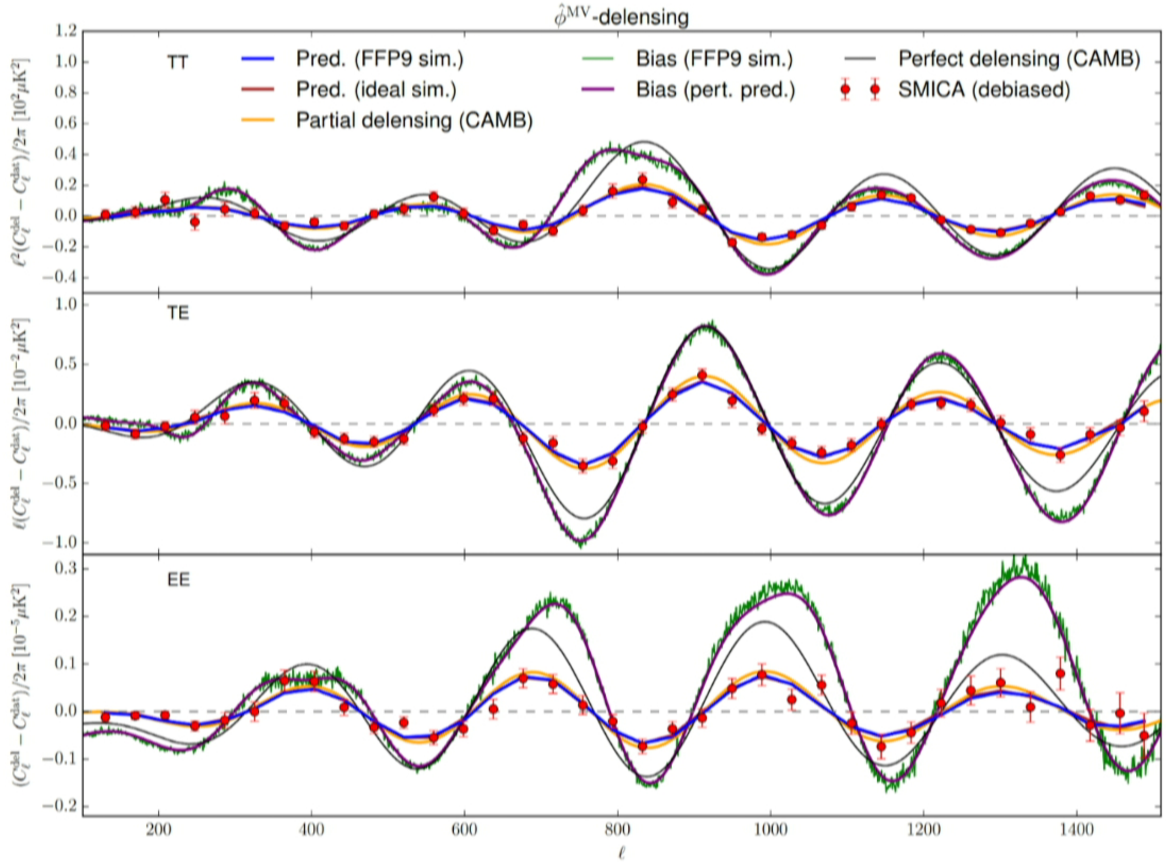
Sehgal, **MM**, Sherwin, van Engelen 2016

Further reduction in S/N due to noisier lensing maps



Alternatives + future work

- Alternatively, model the bias
- Sensitive to simulation mismatch at linear order
- Planck delensing detected at 26σ **(Carron, Lewis, Challinor 2016)** →



Alternatives + future work

- Write realization-dependent estimators for the biases
  (4-point and 6-point polyspectra)
- Demonstrated for B-mode delensing
- Robust to simulation mismatch, minimal S/N loss
- For T/E delensing, higher order correlations could matter (8-point)
  Not yet demonstrated, more work needed.

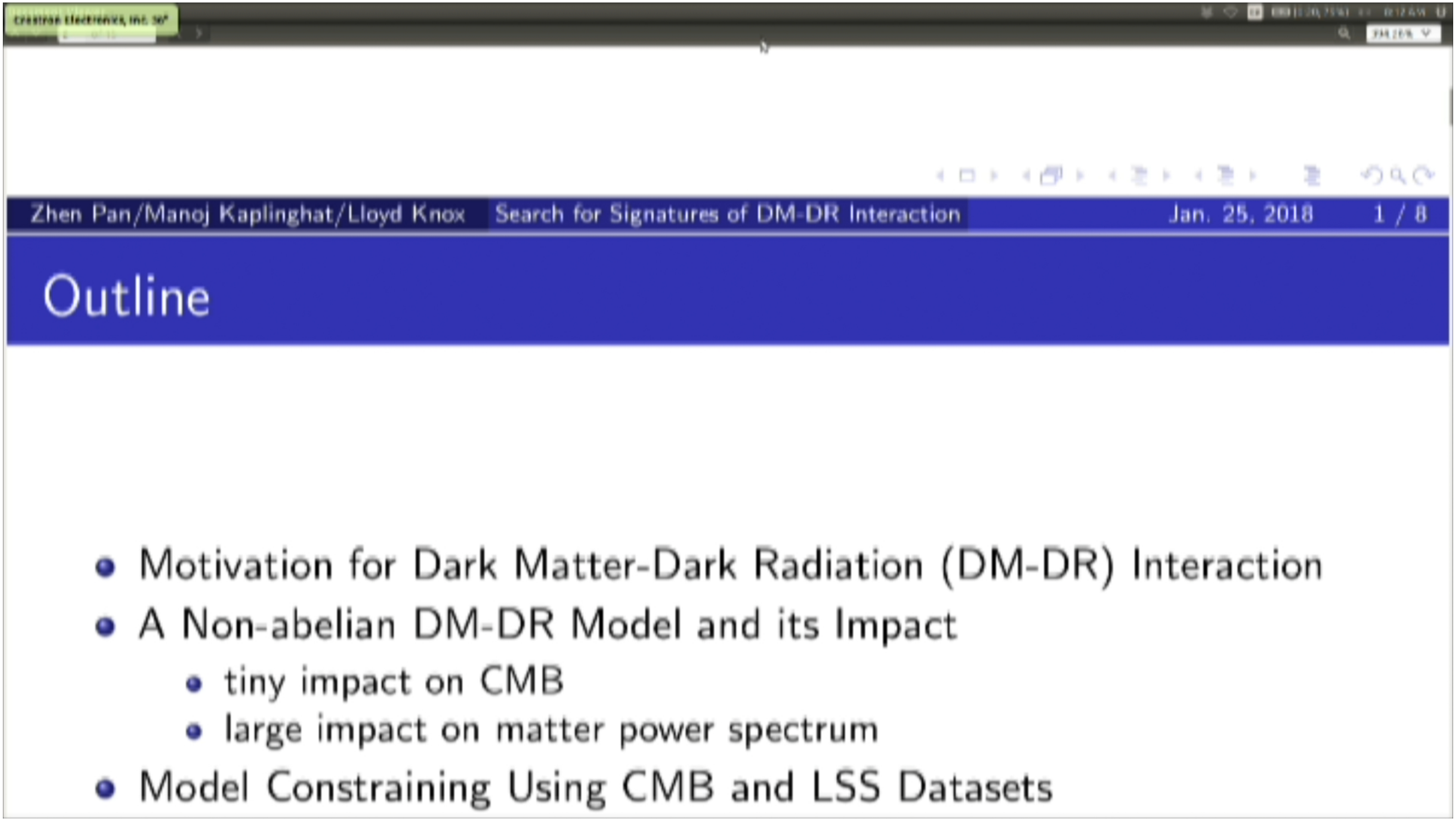
See:
Namikawa 2017

Crestron Electronics, Inc. 30"

Searching for Signatures of Dark Matter-Dark Radiation Interaction in Observations of Large-Scale Structure

Zhen Pan/Manoj Kaplinghat/Lloyd Knox

Jan. 25, 2018 @ Perimeter Institute


Zhen Pan/Manoj Kaplinghat/Lloyd Knox
Search for Signatures of DM-DR Interaction
Jan. 25, 2018
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Outline
Motivation for Dark Matter-Dark Radiation (DM-DR) Interaction
A Non-abelian DM-DR Model and its Impact
tiny impact on CMB
large impact on matter power spectrum
Model Constraining Using CMB and LSS Datasets

- Model Constraining Using CMB and LSS Datasets
    - Planck SZ
    - Planck Lensing and DES
    - Lyman-α
- Summary

Motivation: σ_8 tension

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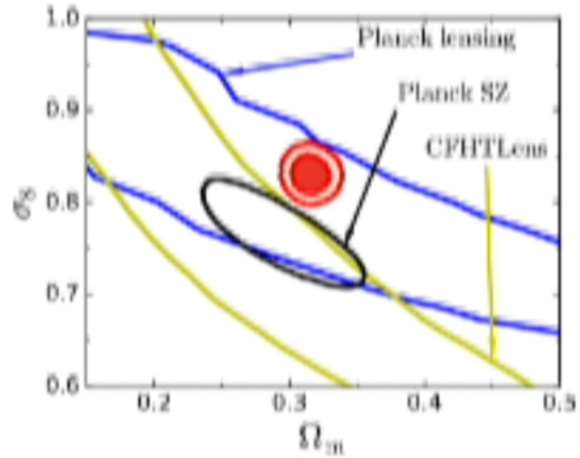

Figure : "directly" measured σ_8 from LSS v.s. CMB + ΛCDM derived σ_8

Motivation: σ_8 tension

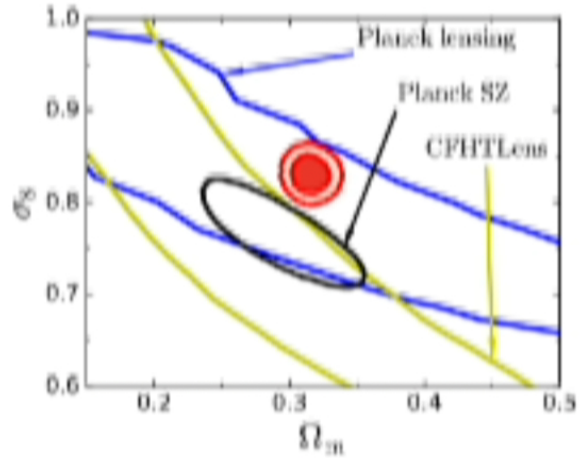

Figure : "directly" measured σ_8 from LSS v.s. CMB + ΛCDM derived σ_8

Take Away:

1. The CMB-SZ tension is the largest.

2. The underlying physics of SZ is most complicated.

A Non-abelian dark sector model

Buen-Abad et al. (2015): Dark Matter → Dirac fermion

$$\sim (1,3)_0, \quad \text{Standard Model } (SU(3)_c, SU(2)_w)_{U(1)_Y}$$

and

$$\sim N, \quad \text{dark sector } SU(N)_d$$

Dark Radiation → associated $SU(N)_d$ gauge field

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Take Away:
(DM, DR) ↔(quark, gluon), therefore DM-DR, DR-DR

Impact on matter power spectrum

$$\dot{\delta}_{\rm dm} = -\theta_{\rm dm} + 3\dot{\phi},$$
$$\dot{\theta}_{\rm dm} = \frac{\dot{a}}{a}\theta_{\rm dm} + k^2\psi + a\Gamma(\theta_{\rm drf} - \theta_{\rm dm}),$$
$$\dot{\delta}_{\rm drf} = -\frac{4}{3}\theta_{\rm drf} + 4\dot{\phi},$$
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where $\Gamma = \Gamma_0/a^2$.

Parameter space: ΛCDM + $(\Gamma_0, N_{\rm drf})$

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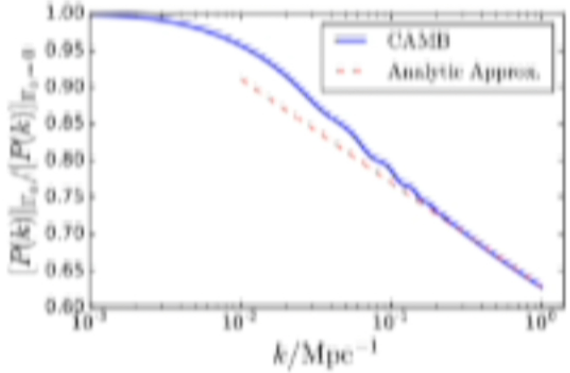

Figure : DM-DR interaction induced matter power suppression for $N_{\rm drf} = 0.5$, $\Gamma_0 = 2\times10^{-7}{\rm Mpc}^{-1}$.

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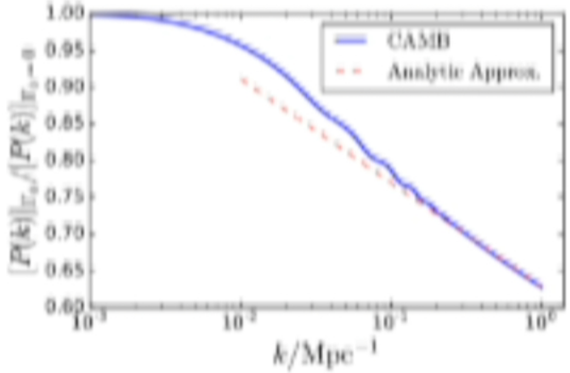

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Model Constraining: Planck CMB + Planck SZ

SZ: $L_X \to M_X$ via a hydrodynamical model

$$M_x = (1 - b)M_{\rm true}$$

From sims, $(1 - b) \sim 0.8$;
From obs,

$$1 - b = 0.780 \pm 0.092 \text{ [CCCP]}.$$

Previous works: $1 - b = 0.8$,

$$10^7\Gamma_0(\mathrm{Mpc}^{-1}) = 1.61 \pm 0.54$$

Lesgourgues et.al (2015), Krall et.al (2017), Buen-Abad(2017)

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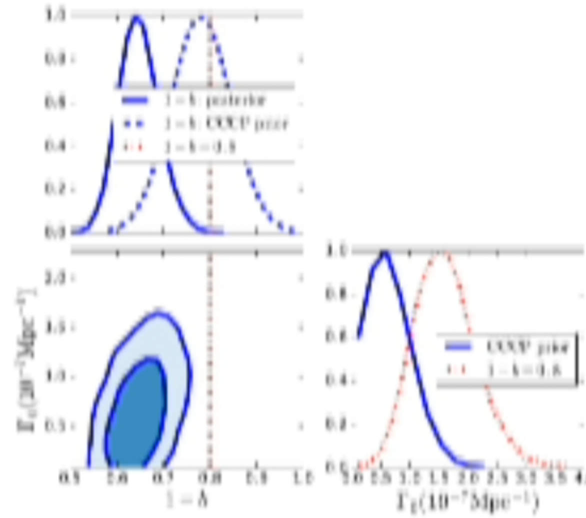

CCCP prior on $1 - b$,

$$10^7 \Gamma_0 (\rm Mpc^{-1}) < 1.36 \ (2\sigma)$$

Model Constraining: Planck Lensing, DES, Ly-α

Planck CMB+Planck Lensing+DES

$$10^7\Gamma_0(\mathrm{Mpc}^{-1}) < 1.43\ (2\sigma)$$

Model Constraining: Planck Lensing, DES, Ly-α

Planck CMB+Planck Lensing+DES

$$10^7\Gamma_0(\mathrm{Mpc}^{-1}) < 1.43\ (2\sigma)$$

Ly-α is sensitive to smaller scale $k \sim \mathrm{Mpc}^{-1}$

$$\Delta_L^2 = k^3 P_L(k,z)/2\pi^2$$

$$n_{\rm eff} = d\ln P_L(k,z)/d\ln k$$

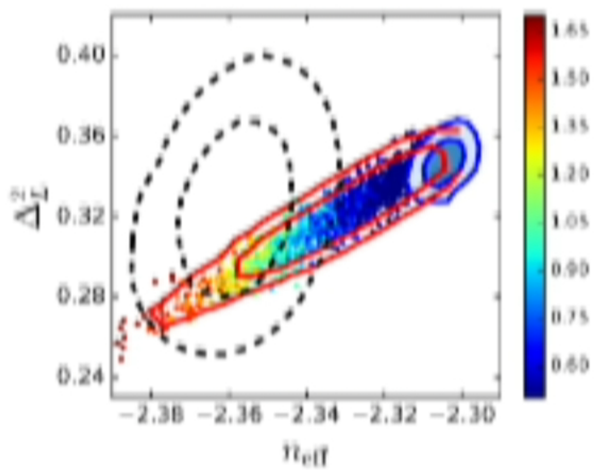

Figure : Dashed: Ly-α Palanque-Delabrouille et.al (2013); Blue: ΛCDM//Planck CMB; Red: DM-DR // Planck CMB+Planck Lensing+DES; Color bar: $10^7\Gamma_0$

Summary

1. The σ_8 tension motivated the DM-DR interaction model.

2. The interaction is NOT detected using Planck CMB+SZ data, due to the $1 - b$ uncertainty.

3. The interaction is NOT detected using Planck CMB+Lensing+DES, due to the mild tension in ΛCDM.

4. Ly-α is sensitive to smaller scale matter power spectrum, and might be a working direction.