Lensing auto-spectrum

2023 CMB-S4 spring collaboration meeting
Science Book 2nd ed. kickoff II
Cross-correlation science and CMB secondaries

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CMB-S4

Cosmology from CMB lensing auto-spectrum: sum of neutrino masses

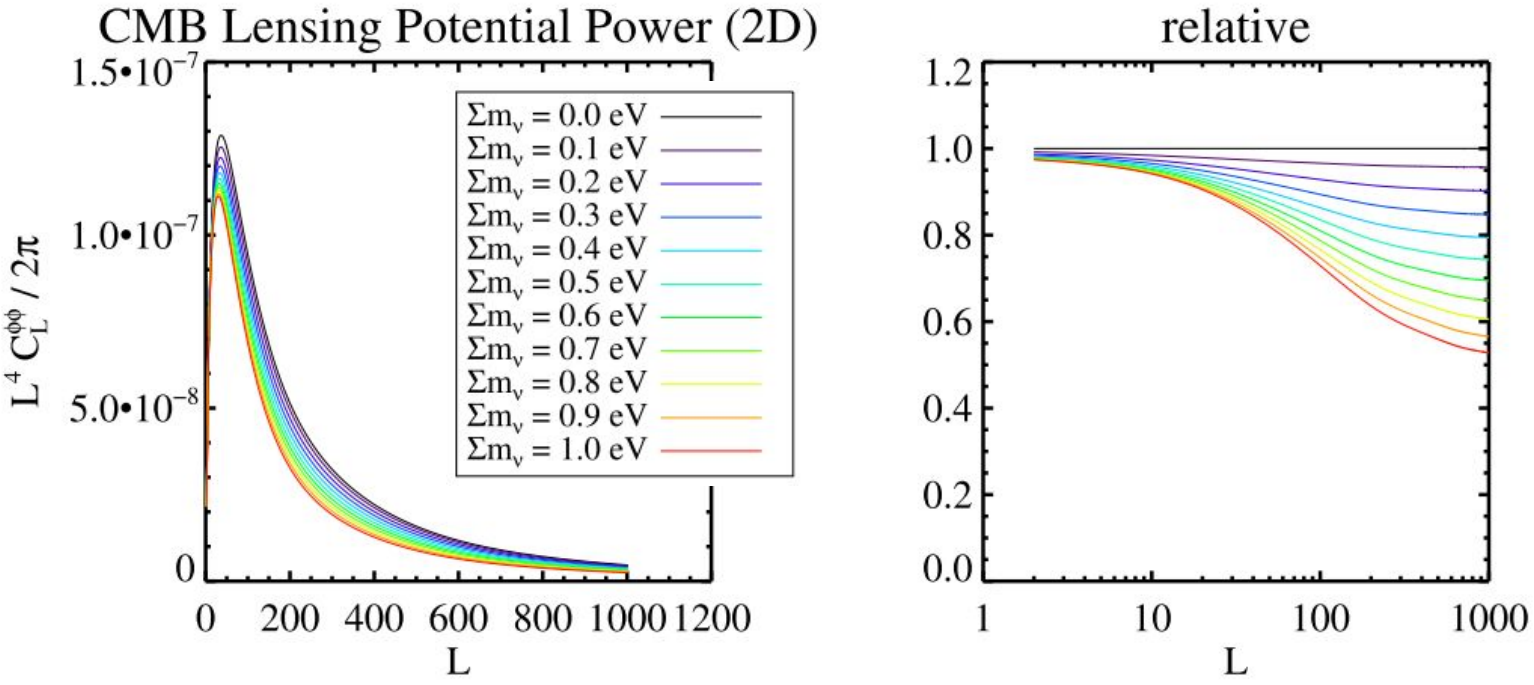
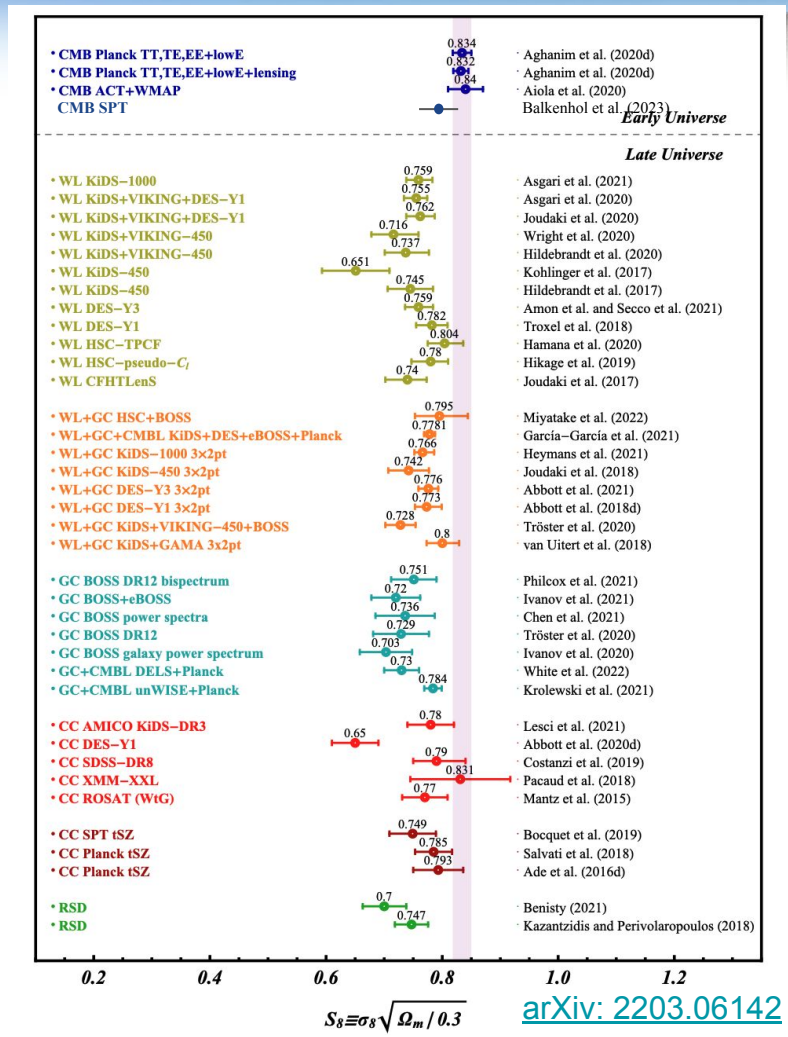


Fig.14 of Science Book 1st ed.

Cosmology from CMB lensing auto-spectrum: S8 tension?

- Late universe measurements of S8 are consistently low across a variety of methods compared to S8 inferred from primary CMB.
- 2-3σ difference against Planck.
- When combined with primary CMB, CMB-S4 will improve σ(S8) by factor of a few compared to Planck*.

* might be resolved before CMB-S4 (similarly for H_0 tension; See e.g. Baxter & Sherwin 2021 for CMB lensing sensitivity to H_0)



arXiv: 2203.06142

Science book 1st edition

Non-exhaustive summary of lensing section:

- Forecasts of σ(M***ν***); accompanying ΔClϕϕ(M***ν***)/Clϕϕ(M***ν***=0).
- Lensing spectrum noise curves (N0) from QE for stages 2, 3, 4 experiments.
- Optimal lensing noise from EB.
- σ(M***ν***) from lensing spectrum with delensed primary CMB bandpowers.
- Discussion on impact of Galactic and extragalactic foregrounds on biases to lensing spectrum measurements.

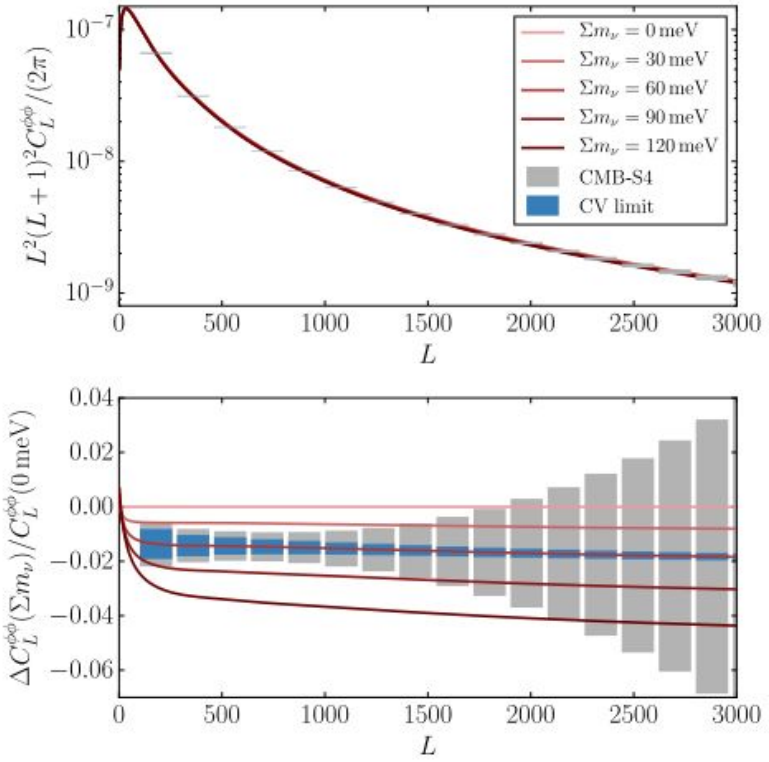
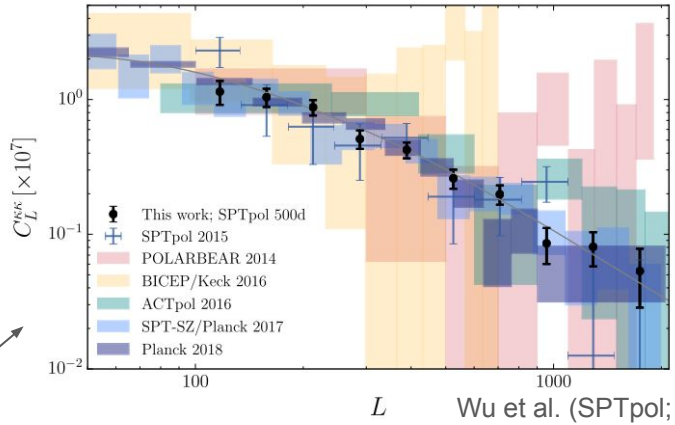


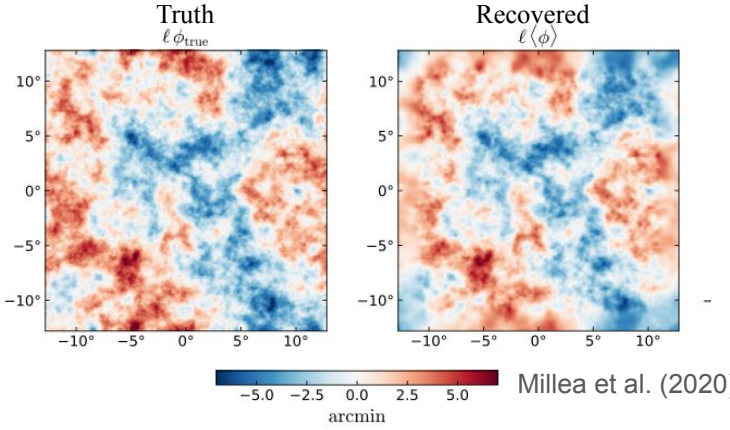
Fig.49 of Science Book 1st ed.

Lots of progress and new questions since then

- Broader cosmological community
  - DESI observing exceeds expectation (implications for M***ν***).
  - S8 tension is drawing attention: Stress-testing of LCDM model/consistency across experiments is now a lot more emphasized.
  - Katrin has had new upper limit on electron neutrino mass.
- Lensing
  - New lensing spectrum measurements using data from current-generation experiments.
  - Development and application of new foreground-immune estimators.
  - Maturing of optimal methods / iterative lensing estimators



Wu et al. (SPTpol; 2019)



Millea et al. (2020)

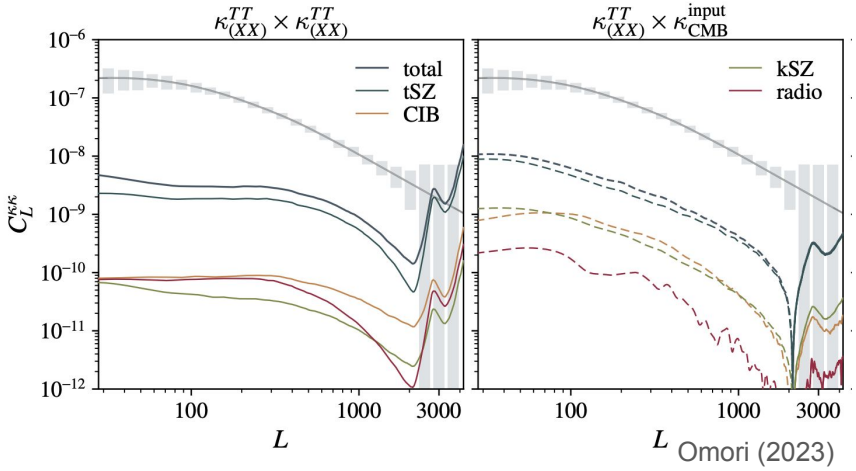
Current experiments are great testbeds for new techniques useful for CMB-S4

- ACT DR6/SO have wide sky coverage; conducive to developing analysis tools that counter issues more common in wide area cases, such as
  - Brighter Galactic foregrounds
  - More inhomogeneous noise
- SPT-3G full survey has similar depth to CMB-S4 wide area survey; conducive to developing tools that leverage optimal lensing, and counter issues common in deep cases, such as point source masking.
- Both surveys rely on CMB T maps for lensing S/N: testing (extragalactic) foreground mitigation strategies.

(E.g. Osbourne et al. (2013) van Engelen et al. (2013);; Namikawa et al. (2013); Madhavacheril & Hill (2018); Schaan & Ferraro (2019); Sailor, Ferraro, Schaan (2020, 2023); Sailor et al.(2021); Darwish et al. (2021); Raghunathan & Omori (2023))

ACTvertisement: Webinar of ACT DR6 lensing results next Tuesday (Apr 11)! "9400 sq. deg. map made from CMB maps with rough white noise of 12uK-arcmin"

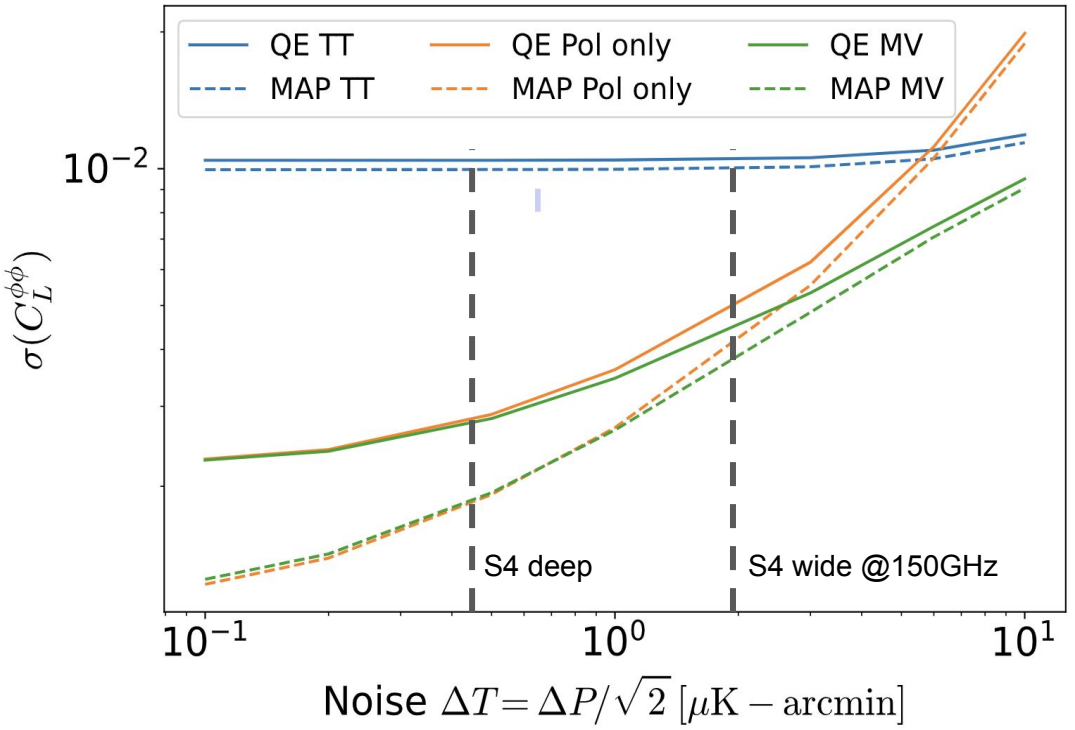
Biases to lensing auto-spec from extragalactic foregrounds



Omori (2023)

Development of techniques needed for the extremely low-noise regime of CMB-S4

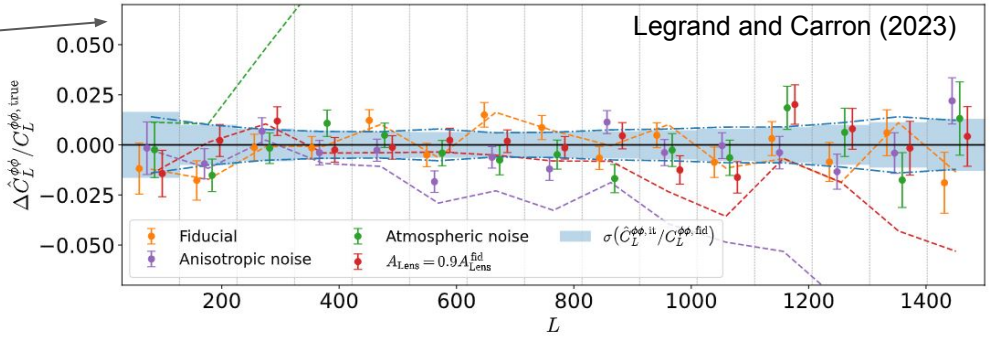
- At CMB-S4 noise levels, beyond QE estimators provide additional S/N.
- T map adds some (small) S/N for wide-field survey.



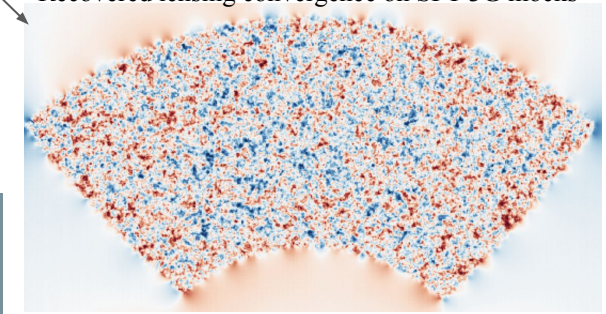
Plot by Louis Legrand

Beyond QE development

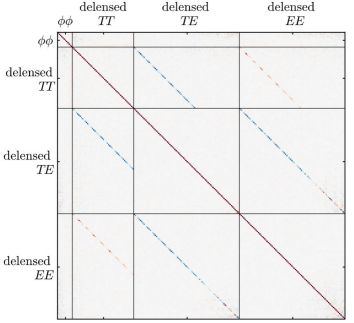
- Iterative reconstruction of ϕ; Unbiased recovery of lensing spectrum. Tested on simulations that mimic realistic conditions (with masking, anisotropic and atmospheric noise…)
- MUSE estimate of ϕ, delensed CMB bandpowers, and cosmological parameters. Testing on SPT-3G mocks.
- Both methods start from same Bayesian posterior of CMB and ϕ fields, and differ from approach to parameter constraints.



Recovered lensing convergence on SPT-3G mocks



PBDR-wide MUSE bandpower covariance



Simple iterated N0 matches sim-based noise calculations; i.e. forecasts using N0 are pretty close to what we can actually get.

Plots by Fei Ge, Michael Doohan, Marius Millea

Potential updates in second edition

- Updating forecasts to use iterated N0 for the lensing spectrum noise (Maps2Cell DRAFT tool; FisherLens; class_delens).
    - Note: σ(Mν) doesn't change much using QE N0 or iterated N0 (See Legrand and Carron arXiv:2112.05764).
- Forecast with DESI (updated performance), DESI-II?, Spec-V?, LIM surveys?
- Forecast S8 (and other cosmo params) in conjunction with delensed TT/TE/EE/BB power spectra.
- Update discussion of optimal lensing / iterative lensing reconstruction.
- Update discussion of foreground-mitigation methods.
- Other (may not be lensing but also higher-order stats) ideas?
    - Curl spectrum detection
    - Cosmic birefringence (monopole in EB, anisotropy through 4-pt/optimal estimator)
    - Patchy tau
    - Your ideas!