

Meeting Notes: May 30, 17

Overall goal: calculate cross-correlations between CMB lensing and LSS.

- Want $C_\ell^{\kappa\kappa}$ which probes σ_8^2 ; $C_\ell^{\kappa g}$ which probes $b\sigma_8^2$; C_ℓ^{gg} which probes $b^2\sigma_8^2$.
 - Since deal with galaxies in specific redshift bins, explicitly consider auto- and cross-spectra for the bins.
 - Say i th z -bin has central redshift z_i . Adopt the convention of writing the cross spectrum as $C_\ell^{\kappa i}$ which probes $b(z_i)\sigma_8^2(z_i)$ and C_ℓ^{ii} which probes $b^2(z_i)\sigma_8^2(z_i)$. **Should σ_8 have the z -dependence? If yes, if/how does z -bin dependence come in through $C_\ell^{\kappa\kappa}$? MM: z -dependence of σ_8 comes in through the growth factor. $P(k, z) \approx D^2(z)P(k, z_0)$ and $C_\ell^{\kappa\kappa}$ in turn depends on it through $C_\ell^{\kappa\kappa} = \int dz W^2(z)P(k = \ell/\chi, z)$**
- Expect coupled systematics due to dust uncertainties to be the biggest source of problems. Need to look at cross-correlations between CMB lensing and dust uncertainties.
- Will need to think about two kinds of dust contributions: 1) MW dust extinguishes background galaxies; its microwave emission affects lensing, and 2) CIB affects lensing and hence correlates with galaxy distribution.

Convergence Field

Know

$$\kappa(x) = \int_0^\infty dz W^c(z) \delta(x, z) \quad (1)$$

where $W^c(z)$ is the CMB window function, $\delta(x, z)$ is the matter density field, and x is the position on the sky.

Now, since we have LSS for different redshift bins and hence have $\delta(x, z)$ in Equation 1, we can break $\kappa(x)$ as contributions from different redshift bins:

$$\kappa(x) = \int_0^{z_1} dz W^c(z) \delta(x, z) + \int_{z_1}^{z_2} dz W^c(z) \delta(x, z) + \dots + \int_{z_n}^\infty dz W^c(z) \delta(x, z) \quad (2)$$

We can choose redshift bins such that the CMB window function $W^c(z)$ can be approximated as a top-hat in the given bin (with central redshift z_i). Then we have

$$\kappa(x) = \sum_{i=1}^n W(z_i) \delta(x, z_i) + \int_{z_n}^\infty dz W^c(z) \delta(x, z) \quad (3)$$

where the last integral needs to be evaluated in full since neither $W^c(z)$ nor $\delta(x, z)$ is a constant for any broad z -bin.

Cross-Correlations

In Limber approximation, the cross-correlation can be written in closed form as

$$C_\ell^{\kappa g} = \int_0^\infty dz W^g(z) W^c(z) b(z) P_\ell^{true}(k, z) \quad (4)$$

where $W^g(z)$ is the LSS window function, $W^c(z)$ is the CMB window function and $P_\ell^{true}(k, z)$ is the true matter power spectrum as a function of redshift.

Observed Power Spectrum

We can use Equation 4 to incorporate the effects of artifacts induced in the observed matter power spectrum. For instance, we know From Awan+ 2016 and LSST Observing Strategy White Paper that

$$P_{\ell}^{obs}(k, z) = W_{\ell}^2 P_{\ell}^{true}(k, z) + P_{\ell}^{OS}(k, z) \quad (5)$$

where W_{ℓ} is the survey window function.

Overall Plan

- Use `orphics` to find the auto- and cross-correlations using analogs of Equation 4, i.e., $C_{\ell}^{\kappa\kappa}, C_{\ell}^{\kappa i}, C_{\ell}^{ii}$. For W^g , start with assuming its a top-hat in each z -bin.
- Get realizations of κ and density maps using synfast: input $C_{\ell}^{\kappa\kappa}, C_{\ell}^{\kappa i}, C_{\ell}^{ii}$ as the TE fields.
- Create a lensed CMB map using the realized κ map.
- Add dust artifacts to the lensed CMB map and LSS maps. Adding dust to lensing CMB maps makes sure dust contamination enters through the bispectrum $\langle TTg \rangle$ as expected.
- Add OS artifacts to the realized map of LSS. These artifacts are calculate using LSST Metric Analysis Framework pipeline.
- Cross-correlate the with-artifacts maps to see the amount of spurious power.

To-Do

- Humna: Look at Baxter+ (SPT/DES), Miyatake+ (Planck/CMASS), Schaan et al.
- Humna: Set up CAMB.
- Humna: Set up `orphics` to get $W^c(z)$.
- Humna: update the current work to use `orphics` for top hat LSS window function. Compare results (current) without the pipeline,
- Need to figure out dust systematics for both CMB optical frequencies. Who to talk to? David Alonso; Alex Van Engelen, Reza Ansari?
- Humna: provide Mat with κ and dust maps.
- Mat: Create the lensed CMB map and return reconstructed κ map.
- Humna: Run LSST OS artifacts pipeline at $N_{side}=1024$. No need to get higher- z spectra from Hu as wont be using his data as true LSS but CAMB's. Nelson's mock catalogs have high- z spectra so need to incorporate them to calculate the artifacts for all relevant redshift bins.
- All: Do a literature review to see what has been done in the field so far.