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 ith 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 $C_\ell^{\kappa\kappa}$?
- 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

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

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:

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

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

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

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

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

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

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

where W_ℓ is the survey window function.

Plan

- Use CAMB to get $P(k,z)$. Does it give $P_l(k,z)$? Otherwise, how to calculate?
- Use $P_\ell(k,z)$ to realize $\delta(x,z)$.
- Find the convergence field using Equation 3; will need $W^c(z)$. Find $C_\ell^{\kappa\kappa}$.
- Find C_ℓ^{ii} using the realized $\delta(x,z)$.
- Find $C_\ell^{\kappa i}$ using Equation 4. For W^g, start with assuming its a top-hat in each z-bin.
- Give synfast $C_\ell^{\kappa\kappa}, C_\ell^{\kappa i}, C_\ell^{ii}$ as the TE fields, which will return a realization of the convergence and density fields as maps.
- Cross-correlate the maps.
- Add OS artifacts to the realized map of LSS. These artifacts are calculate using LSST MAF pipeline.
- Dust artifacts will need to be added to both the convergence and LSS maps.
- Cross-correlate the with-artifacts maps to see the amount of spurious power.

To-Do Before Simons Summer Meeting

Goal: have CMB lensing-LSS correlation by Simons meeting (with a simple handle on dust).

- Humna: Look at Baxter+ (SPT/DES), Miyatake+ (Planck/CMASS), Schaan et al.
- Humna: Set up CAMB.
- Mat: Provide $W^c(z)$.
- Humna: Run LSST OS artifacts pipeline at Nside= 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.