Auto- and cross-correlation of the cosmic microwave background lensing and infrared background measured by Planck and Herschel

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CIB maps with Herschel





CIB maps with Herschel



We can find some stripes from the temperature variation in scan direction, especially serious at 500 μ m.

CMB lensing maps with Planck



mask

Our maps are masked by taking a 3σ flux cut and then convolving with the PSF. Such a flux cut, through a mask that removes the bright galaxies, also minimizes the bias coming from those bright sources by reducing shot-noise effects.



Power spectrum measurements

In this work, we calculate the auto- and cross-power spectrum follow the following process used by Cooray et al. (2012).

$$C_{\ell_{i}} = \frac{\sum_{\ell_{1}}^{\ell_{2}} w\left(\ell_{x}, \ell_{y}\right) \widetilde{\mathcal{M}_{X}}\left(\ell_{x}, \ell_{y}\right) \widetilde{\mathcal{M}_{Y}}^{*}\left(\ell_{x}, \ell_{y}\right)}{\sum_{\ell_{1}}^{\ell_{2}} w\left(\ell_{x}, \ell_{y}\right)}$$

In this work, we calculate the auto- and cross-power spectrum follow the following process used by Cooray et al. (2012).

$$C_{\ell} = B_{\ell}^2 T_{\ell} M_{\ell\ell'} \widetilde{C_{\ell'}} + N_{\ell}$$

Where B_I is the beam function, T_I is the map-making transfer function, $M_{II'}$ is the mode coupling matrix, and N_I is the instrumental noise.

Noise Model

We generate the instrumental noise using a simple noise model that is described as follows,

$$N_\ell = N_0 \left[\left(\frac{\ell_0}{\ell} \right)^2 + 1 \right]$$

where the noise is almost white-noise (N₁ \rightarrow constant) at small scales (large I), and show the 1/f-type (N₁ \propto l⁻²) at large angular scales (small I).

Beam Correction

According to the studying in Amblard et al. (2011), the beam function of a symmetric 2D-Gaussian beam can be expanded as,

$$B_{\ell} = \exp\left(\ell^2 \sigma_{beam}^2 / 2\right)$$

where σ_{beam} is the standard deviation of the Gaussian beam, and is defined as,

$$\sigma_{beam} = \theta_{\rm FWHM} / \sqrt{8In2}.$$

The mean FWHM values are 18.1", 25.2" and 36.6" for the 250, 350 and 500 µm maps, respectively.

Mode Coupling Correction

CIB power spectra involve aggressive masks that remove a substantial fraction of the pixels. A consequence of such masking is the breaking up of larger Fourier modes into smaller modes. This results in a shift of power from low-I to high-I.

1. For each I in the power spectrum create many realizations of maps consisting of a pure tone, where $C_m = 1$ if I=m and $C_m = 0$ otherwise.

2. For each of these trial maps, mask the maps and calculate an observed power spectrum.

3. The mode coupling matrix $M_{Im} = C_m(I)$ is the average of the masked power spectra found for the random realizations of model I.

Map-Making Transfer Function

Herschel-SPIRE detectors are only sensitive to relative variations, which insult in the unknown absolute brightness of the measured filed. First, we generate randomly 100 simulated Gaussian realizations of sky, and obtain the timelines with the same scan path as the real observation. Next, subtract the median value in each timeline, and merge the processed timelines to final maps. Finally, The map-making transfer function can be described by $T_1=C_1^{input}/C_1^{output}$

Theoretical model and analysis

$$C_{\ell}^{XY} = \int_0^{z_*} dz \frac{d\chi}{dz} W^X(z) W^Y(z) P(k = \ell/\chi, z)$$

 $W^{\nu}(z) = b \frac{a \overline{j}_{\nu}(z)}{\chi(z)};$

the kernel function,

$$W^{\phi}(z) = -rac{3\Omega_m}{a} \left(rac{H_0}{\ell c}
ight)^2 \left[rac{\chi_*-\chi(z)}{\chi_*}
ight].$$

 $j_\nu(z)$ is the mean emissivity of CIB at frequency $\nu_{\rm r}$

$$\overline{j}_{\nu}(z) \propto a\chi^2(z) \exp\left[-\frac{(z-z_c)^2}{2\sigma_z^2}\right] f_{\nu(1+z)}.$$

where we assume that all galaxies can be described by a graybody spectrum: $f_{\nu} \propto \nu^{\beta} B_{\nu} (\nu, T_d)$

Final Power Spectrum

Thank you