The cross-correlation between CIB and Galaxy Clustering

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Funded by
the European Union
NextGenerationEU

Cosmic Infrared Background Radiation

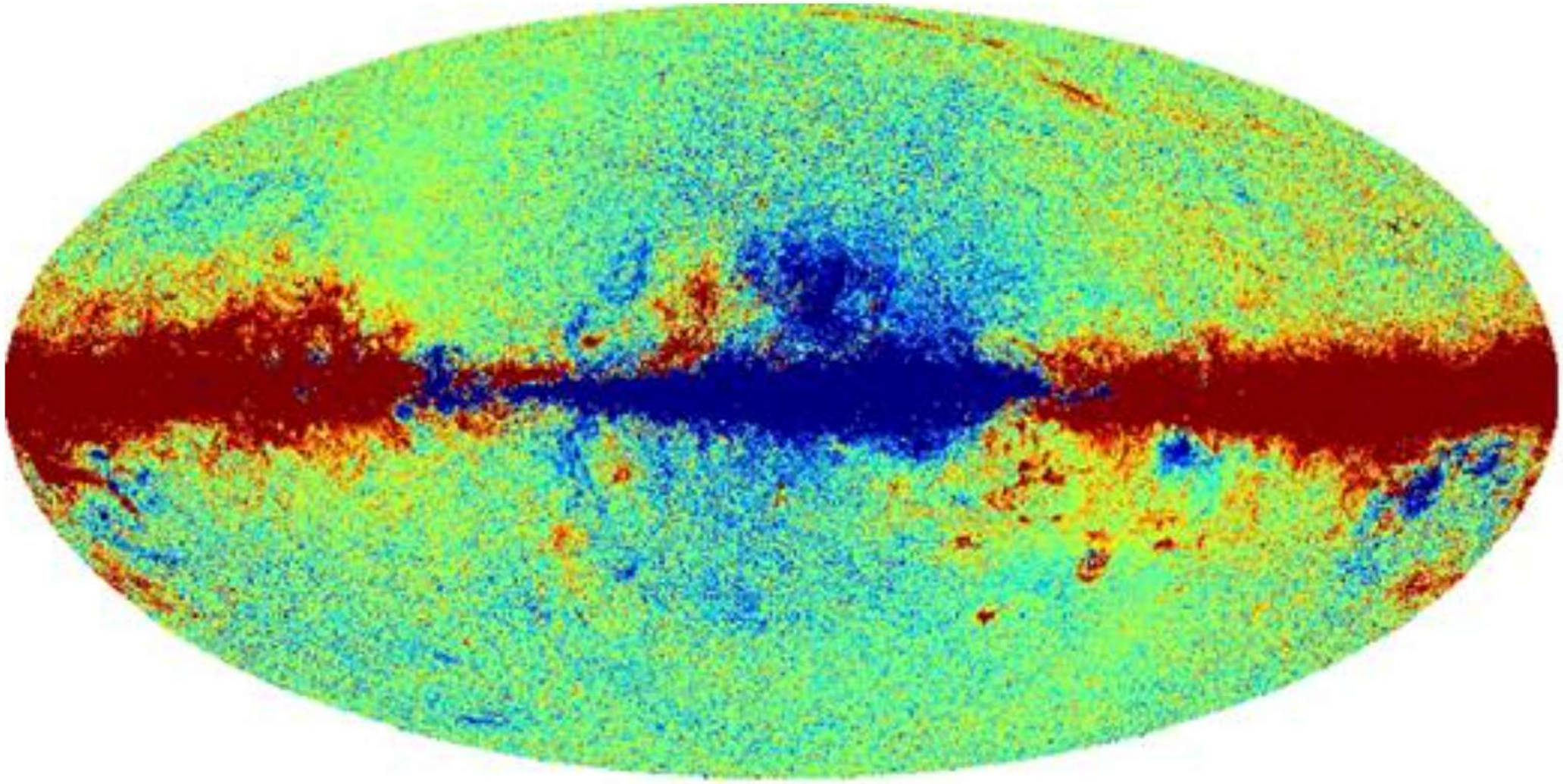
Cosmic Infrared Background Radiation(CIB) mainly comes from the heated dust within the galaxies.

CIB carries the integrated history of star formation between the redshift $1 \leq z \leq 3$, which highly overlaps with the CMB lensing signals.

Without additional information it is not possible to disentangle the contribution to the CIB from sources at different redshifts.

Through the use of galaxy clustering tomography, the CIB contribution from different redshift bins can be constrained.

Cosmic Infrared Background Radiation



[Daniel Lenz, et al.2019]

Halo Model of CIB [Shang, et al. 2012]

$$C_{\ell,\nu\nu'} = \int \frac{dz}{\chi^2}\frac{d\chi}{dz} a^2 \bar{j}(\nu,z)\bar{j}(\nu',z) P_{j,\nu\nu'}(k = l/\chi, z)$$

$$P_{gal}(k,z) = P_{1h}(k,z) + P_{2h}(k,z)$$

$$\begin{aligned} j_\nu(z) \quad = \quad & \int dM \frac{dN}{dM}(z) \frac{1}{4\pi} \left[N_{cen} L_{cen,(1+z)\nu}(M,z) \right. \\ & \left. + \int dm \frac{dn}{dm}(M,z) L_{sat,(1+z)\nu}(m) \right], \end{aligned}$$

Halo Model of CIB [Maniyer, et al. 2021]

$$\frac{\mathrm{d}j_{\nu,\,\mathrm{sub}}}{\mathrm{d}\log M_\mathrm{h}}(M_\mathrm{h},z)=\frac{\mathrm{d}^2N}{\mathrm{d}\log M_\mathrm{h}\mathrm{d}V}\times\chi^2(1+z)$$

$$\frac{\mathrm{d}j_{\nu,\mathrm{c}}}{\mathrm{d}\log M_\mathrm{h}}(M_\mathrm{h},z)=\frac{\mathrm{d}^2N}{\mathrm{d}\log M_\mathrm{h}\mathrm{d}V}\times\chi^2(1+z)\times\frac{\mathrm{SFR}_\mathrm{dc}}{K}\times S_\nu^\mathrm{eff}(z)$$

$$\frac{\mathrm{SFR}}{\mathrm{BAR}}(M_\mathrm{h},z)=\eta=\eta_\mathrm{max}e^{-\frac{(\log M_\mathrm{h}-\log M_\mathrm{max})^2}{2\sigma^2_{M_\mathrm{h}}(z)}},$$

Star Forming Rate Model of CIB

$$\mathrm{SFR}(M,z) = \mathrm{SFR}_c(M,z) + \mathrm{SFR}_S(M,z).$$

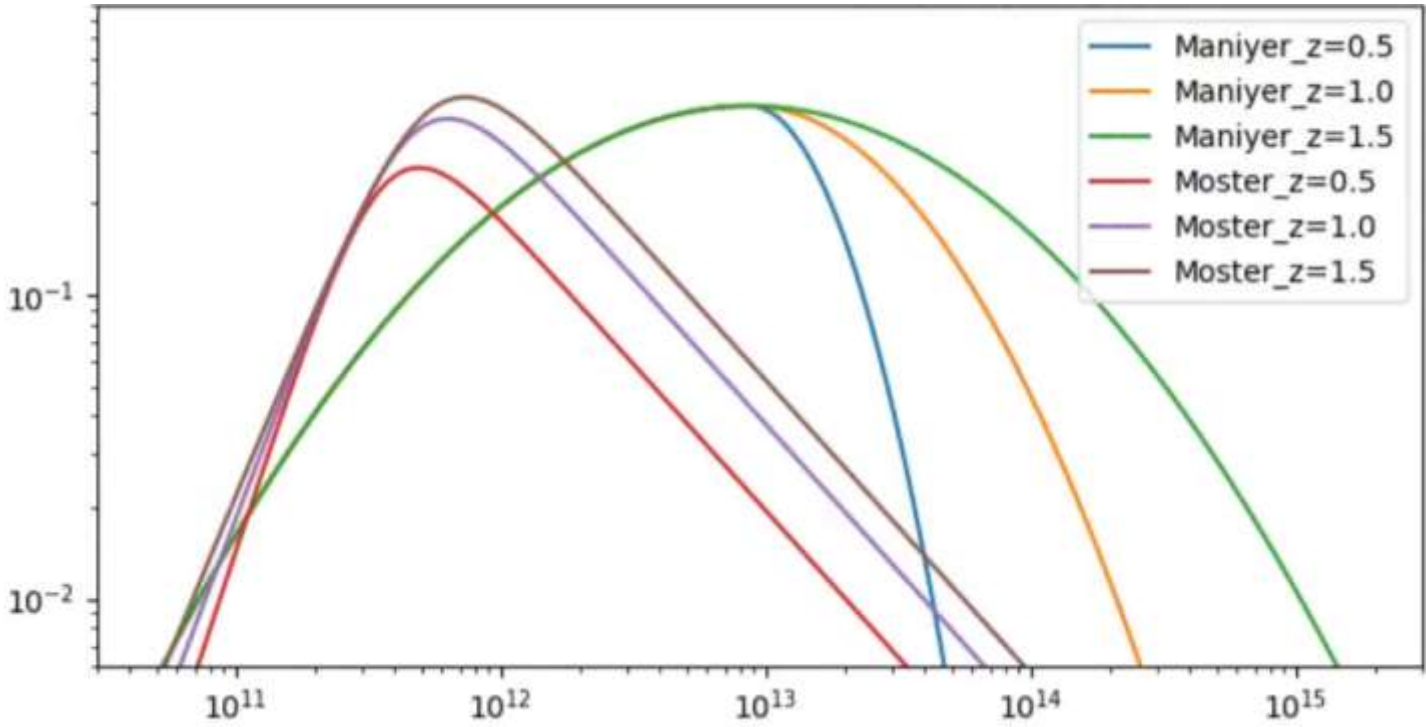
$$\mathrm{SFR}_c(M,z) = \eta(M,z)\,\mathrm{BAR}(M,z)$$

$$\mathrm{BAR}(M,z) = \dot{M}_0 \frac{\Omega_b}{\Omega_M} \left(\frac{M}{10^{12} M_\odot} \right)^{1.1} (1+1.11z) \frac{H(z)}{H_0}$$

[Jego, et al. 2022

Star Forming Rate Model of CIB

$$\eta(M,z) = \frac{2\eta_*}{(M_1/M)^{\beta} + (M/M_1)^{\gamma}}$$

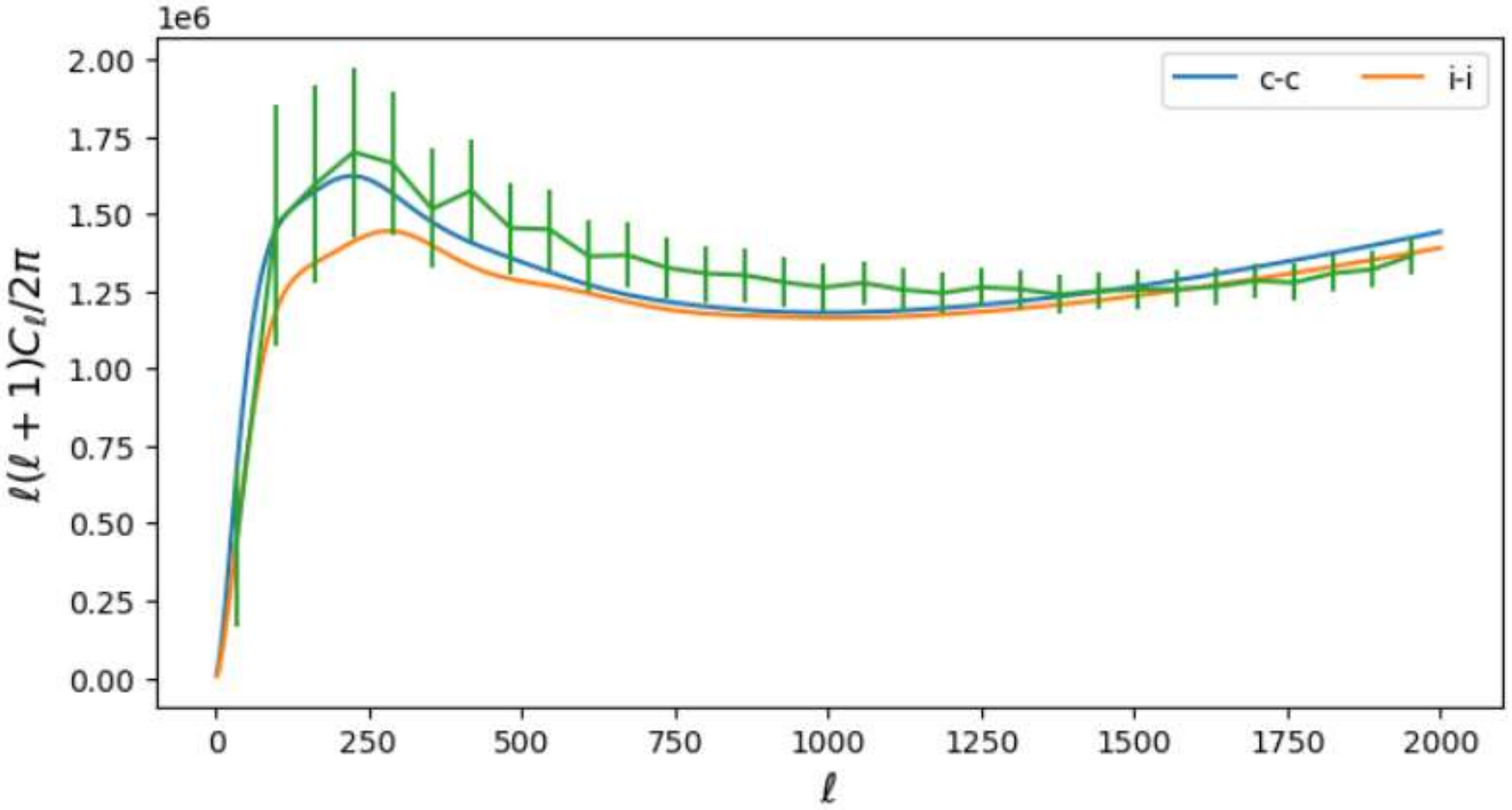


$$\eta(M,z) = \eta_{\max} \exp\left[-\frac{(\log M_{\max} - \log M)^2}{2\sigma_M^2(M,z)}\right]$$

[Jego, et al. 2022]

$$\sigma_M(M,z) = \sigma_{M,0} - \tau\Theta(M - M_{\max})\max(0, z_c - z)$$

Auto-Power Spectrum from Halo Model of CIB



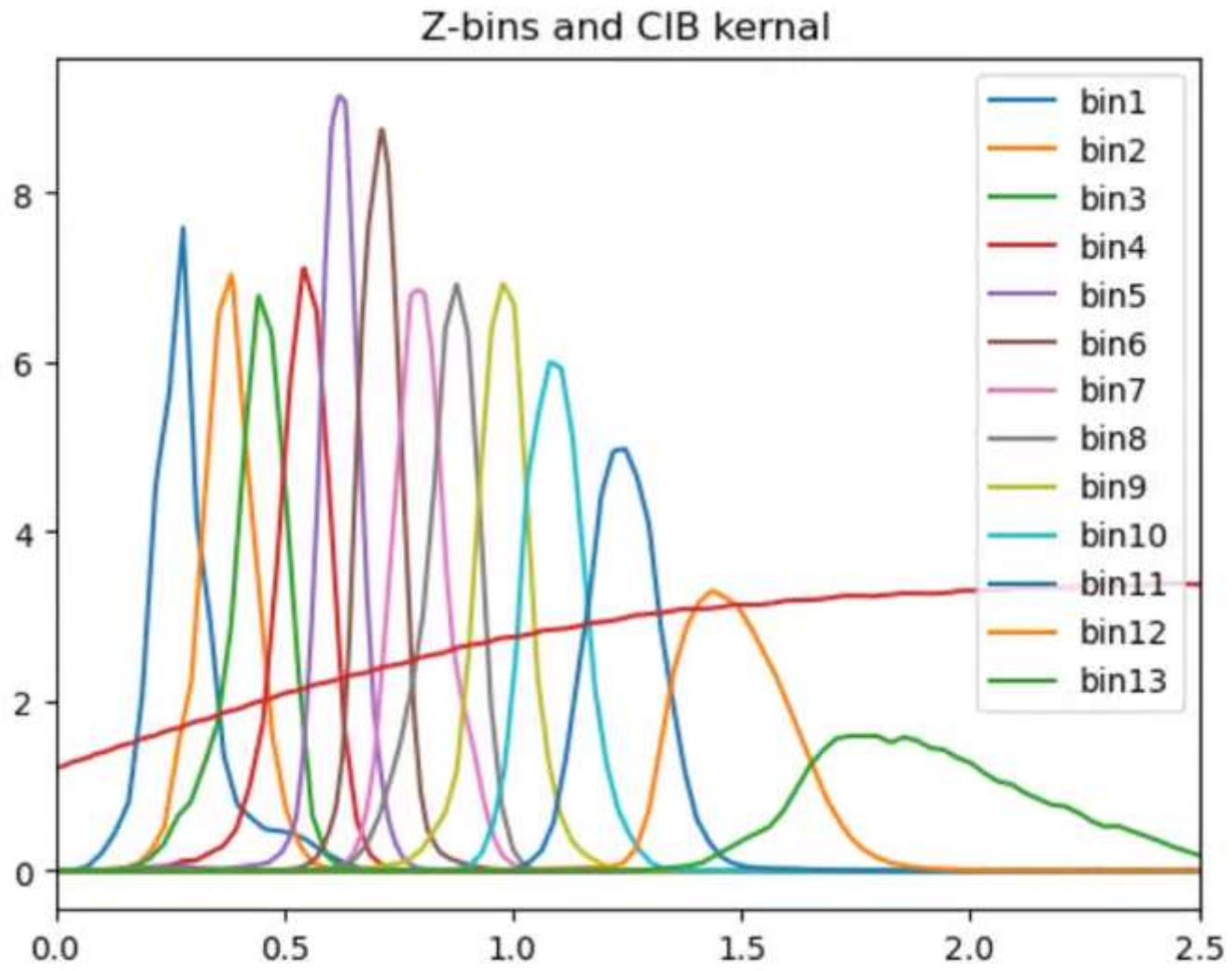
Cross-power spectrum(CIB-LSS tracers)

$$C_\ell^{ab} = 4\pi \int_0^\infty \frac{dk}{k} \mathcal{P}_\Phi(k) \Delta_\ell^a(k) \Delta_\ell^b(k)$$

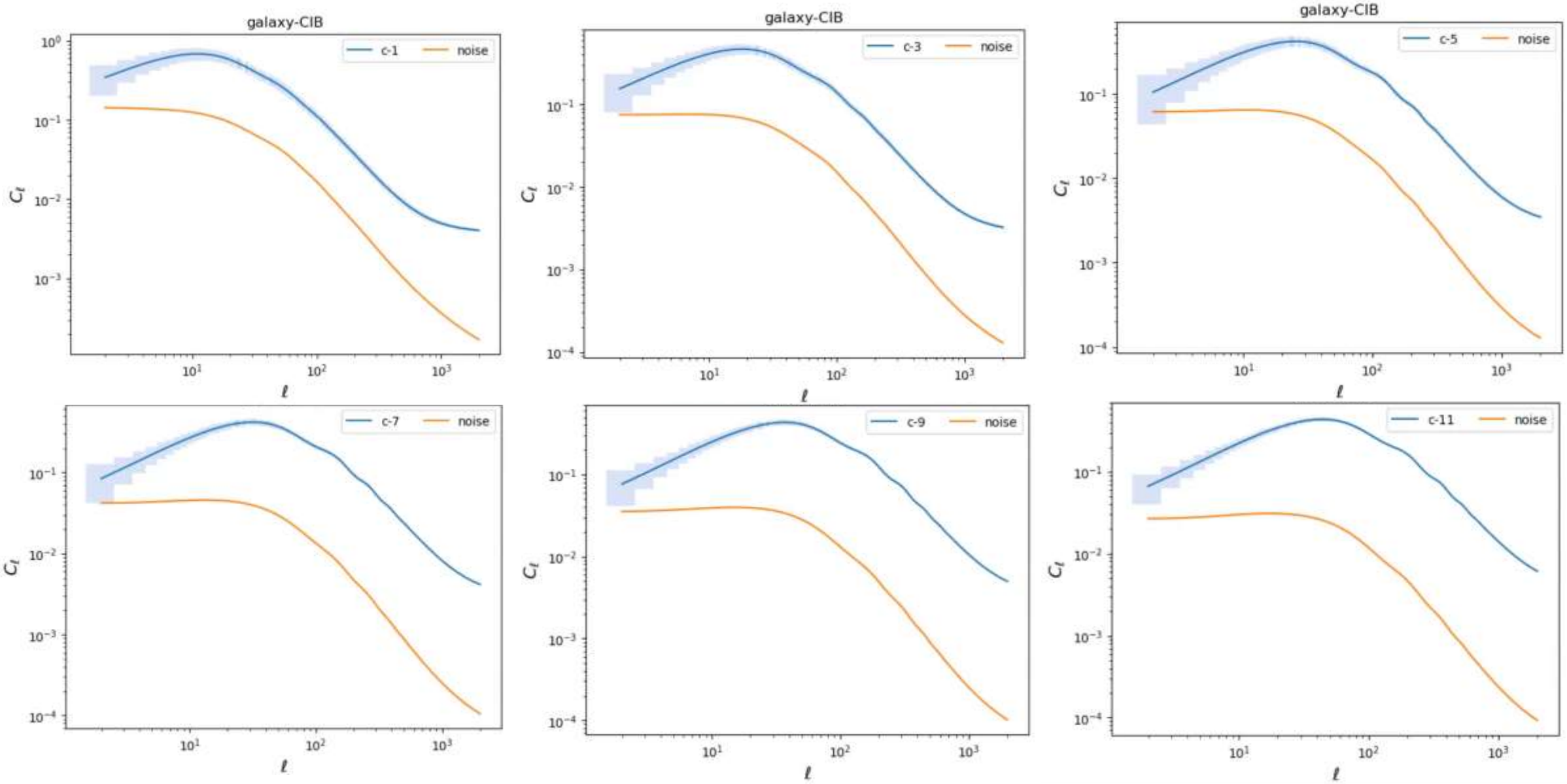
$\Delta_\ell^{\mathrm{D}}(k)$:Galaxy number density transfer function

[PyCCl. 2019]

Equi-populated Euclid Photometric Bins



Cross-power spectrum(CIB-Galaxy clustering)



Power Spectrum Templates

$$C_\ell^{gg} \simeq b_g^2 M_\ell^{gg} + n_{gg}$$

$$C_\rho^{gv} \simeq b_g \langle b\rho_{\rm SFR}\rangle M_\rho^{gv} + n_{gv},$$

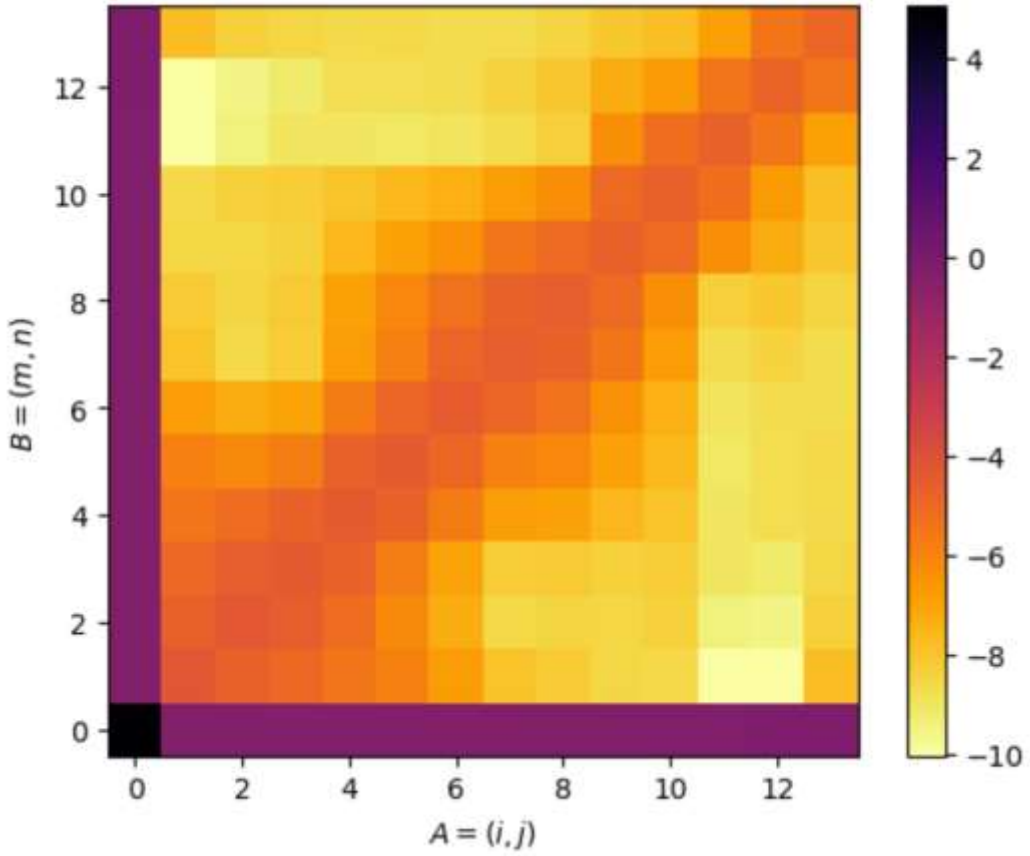
$$M_\ell^{uv} \equiv \int \frac{d\chi}{\chi^2} q_u(\chi) q_v(\chi) P_M\left(\frac{\ell+1/2}{\chi}, z\right)$$

$$n_{uv} \equiv \int \frac{d\chi}{\chi^2} q_u(\chi) q_v(\chi) N_{UV}(z)$$

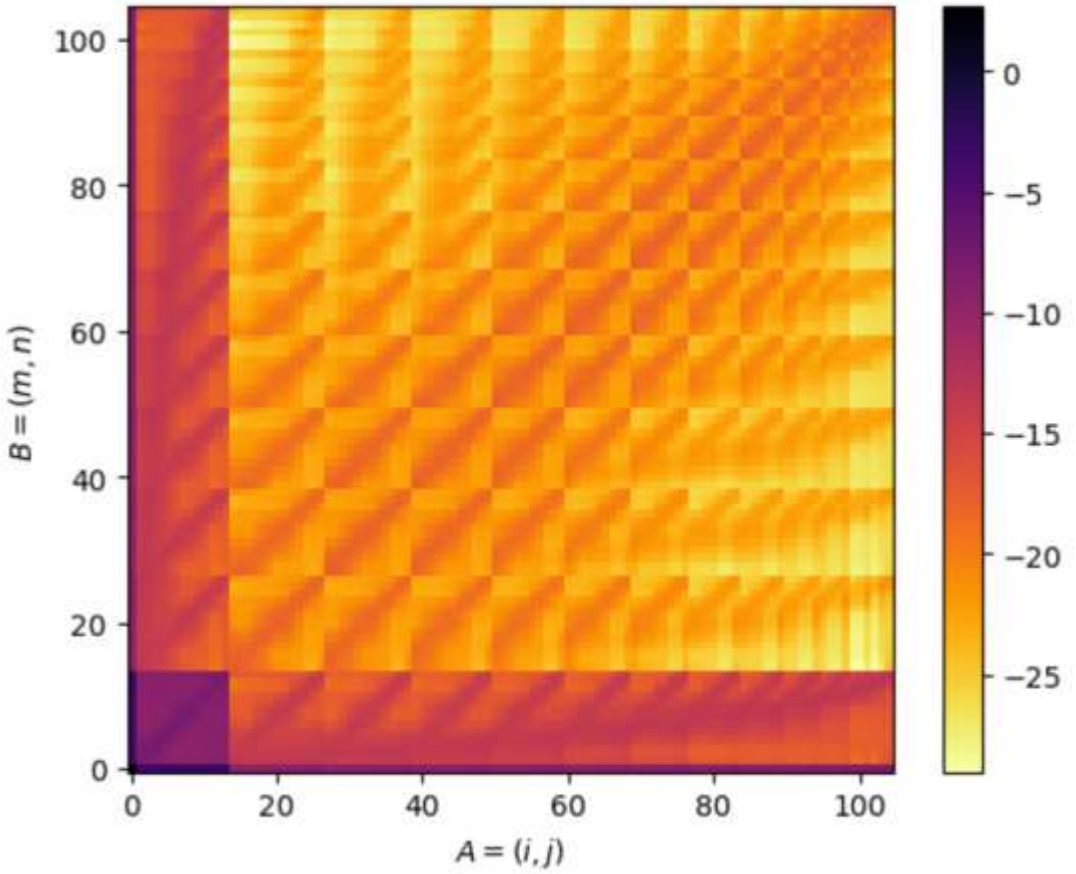
Fisher Matrix Method

$$\mathrm{SNR} = \sqrt{\sum_{\ell,\ell'} C_\ell \mathbb{C}^{-1}_{\ell\ell'} C_{\ell'}}$$

Variance Matrix



Covariance Matrix

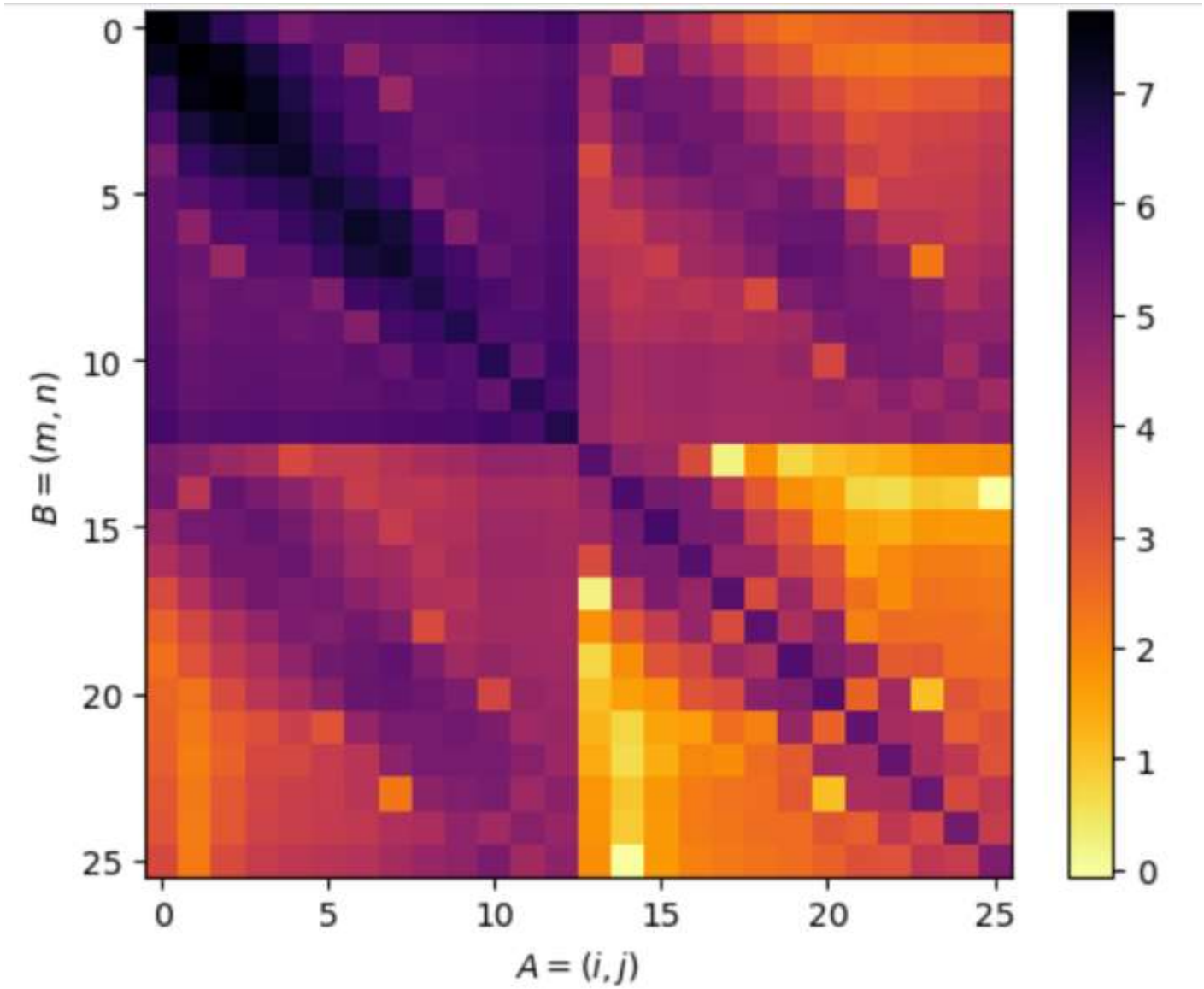


Fisher Matrix Method

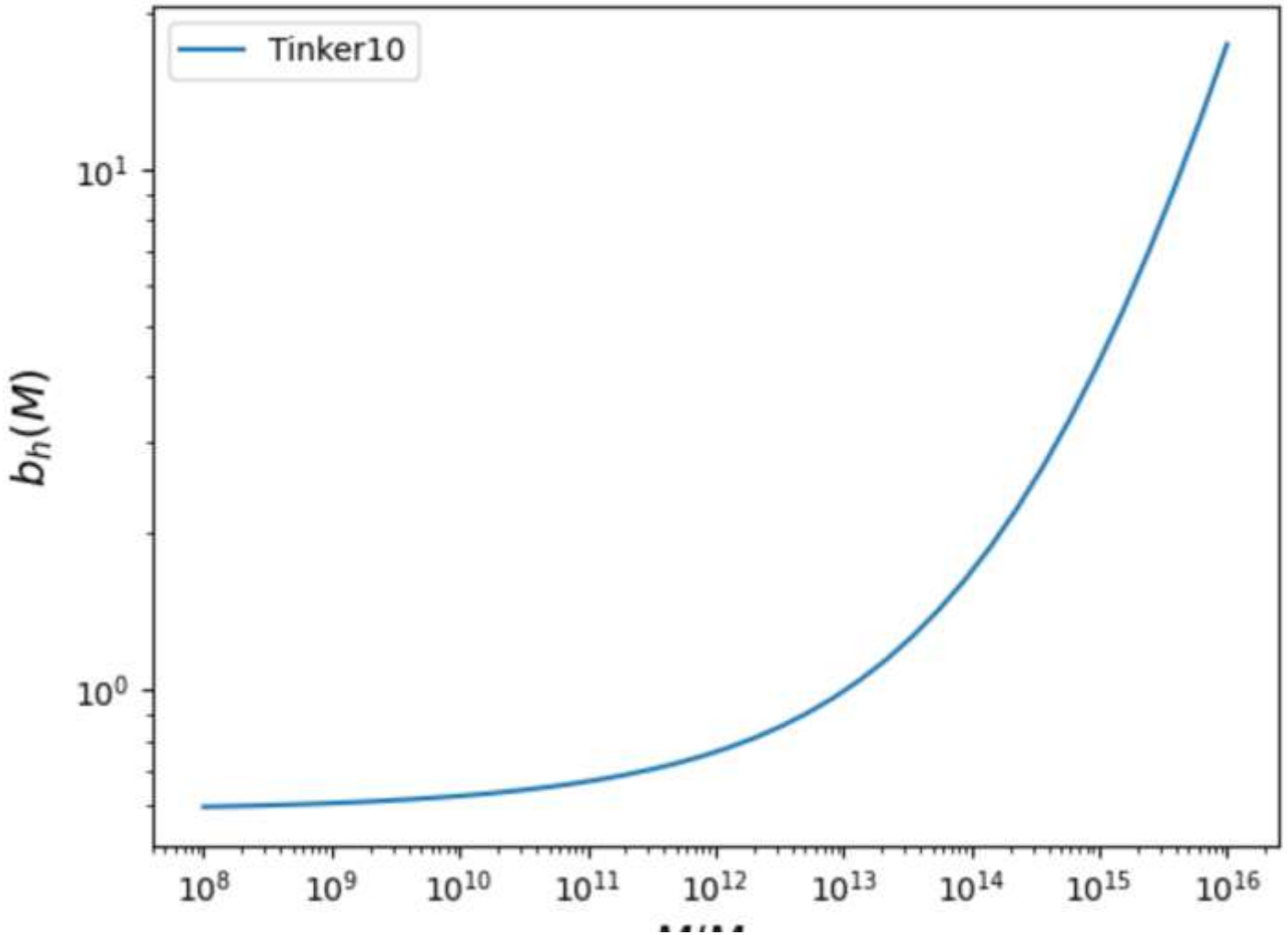
$$\widetilde{F}_{\kappa\lambda} = \sum_{\alpha,\beta} J_{\alpha\kappa} F_{\alpha\beta} J_{\beta\lambda},$$

$$J_{\alpha\kappa} = \frac{\partial\alpha}{\partial\kappa} \qquad C_{\alpha\beta} = \left(\mathrm{F}^{-1}\right)_{\alpha\beta}$$

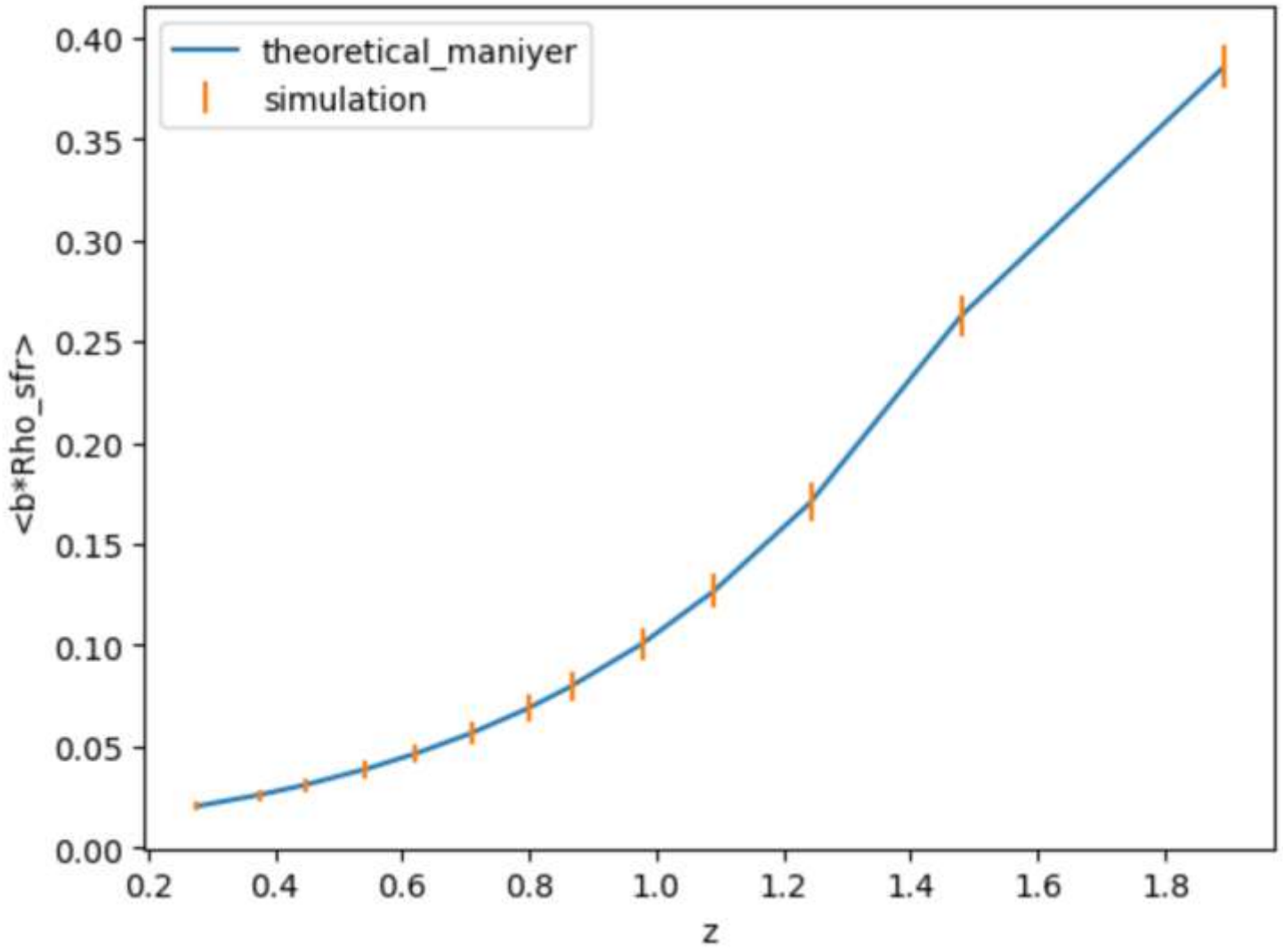
$$\sigma_\alpha = \sqrt{C_{\alpha\alpha}}$$



Fisher Matrix Method [Tinker, et al. 2012]



Fisher Matrix Method



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Summary

- Disentangle the CIB contribution from different z bins through correlation between CIB and galaxy clustering.

Future Work

- Adding systematics to our simulations
- Testing with pseudo-Cls

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THANKS FOR YOUR ATTENTION

Halo term from Shang

$$P_{2h}(k,z) = P_M(M,z) \times \left[\int dM \frac{dN}{dM}(M,z) \frac{N_{gal}(M,z) b(M,z) u(k,z|M)}{\bar{n}_{gal}} \right]^2$$

$$P_{1h}(k,z) = \int dM \frac{dN}{dM}(M,z) \times \frac{2N_{\rm cen}(M) N_{\rm sat}(M) u(k,z|M) + N_{\rm sat}^2(M) u^2(k,z|M)}{\bar{n}_{\rm gal}^2}$$

Halo Model of CIB [Maniyer, et al. 2021]

$$C_{\ell,\nu,\nu'}^{2\,\mathrm{h}} = \iiint \frac{\mathrm{d}\chi}{\mathrm{d}z}\left(\frac{a}{\chi}\right)^2 \left[\frac{\mathrm{d}j_{\nu,c}}{\mathrm{d}\log M_\mathrm{h}} + \frac{\mathrm{d}j_{\nu,\,\mathrm{sub}}}{\mathrm{d}\log M_\mathrm{h}} u(k, M_\mathrm{h}, z)\right] \times \left[\frac{\mathrm{d}j_{\nu',c}}{\mathrm{d}\log M_\mathrm{h}'} + \frac{\mathrm{d}j_{\nu',\,\mathrm{sub}}}{\mathrm{d}\log M_\mathrm{h}'} u(k, M_\mathrm{h}, z)\right] \times b(M_\mathrm{h}, z) b\left(M_\mathrm{h}', z\right) P_\mathrm{lin}(k, z) \mathrm{d}\log M_\mathrm{h} \mathrm{d}\log M_\mathrm{h}' \mathrm{d}z$$

$$C_{\ell,\nu,\nu'}^{1\,\mathrm{h}} = \iint \frac{\mathrm{d}\chi}{\mathrm{d}z}\left(\frac{a}{\chi}\right)^2 \left[\frac{\mathrm{d}j_{\nu,\mathrm{c}}}{\mathrm{d}\log M_\mathrm{h}} \frac{\mathrm{d}j_{\nu',\mathrm{sub}}}{\mathrm{d}\log M_\mathrm{h}} u(k, M_\mathrm{h}, z) + \frac{\mathrm{d}j_{\nu',\mathrm{c}}}{\mathrm{d}\log M_\mathrm{h}} \frac{\mathrm{d}j_{\nu,\mathrm{sub}}}{\mathrm{d}\log M_\mathrm{h}} u(k, M_\mathrm{h}, z) + \frac{\mathrm{d}j_{\nu,\mathrm{sub}}}{\mathrm{d}\log M_\mathrm{h}} \frac{\mathrm{d}j_{\nu',\,\mathrm{sub}}}{\mathrm{d}\log M_\mathrm{h}} u^2(k, M_\mathrm{h}, z)\right] \times \left(\frac{\mathrm{d}^2 N}{\mathrm{d}\log M_\mathrm{h} \mathrm{d}V}\right)^{-1} \mathrm{d}z\, \mathrm{d}\log M_\mathrm{h}$$