Theories and Observations of Dark Energy Final Presentation

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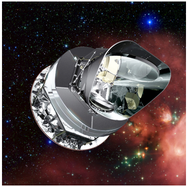
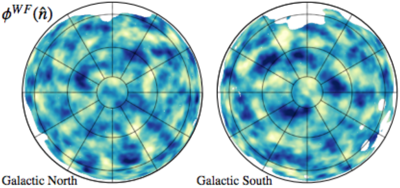
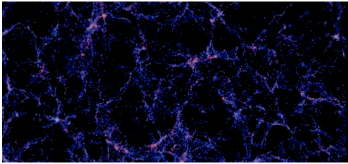
Contents

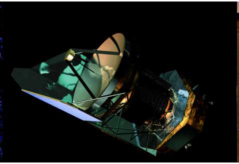
Literature introduction

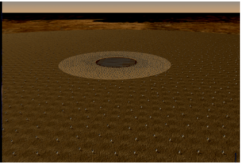




Cross − correlation Between The *CMB Lensing Potential* Measured By $\boxed{\textit{PLANCK}}$ And High-z Sub-mm *Galaxies* Detected By The $\boxed{\textit{HERSCHEL}\text{-ATLAS}}$ *Survey*







CMB Lensing

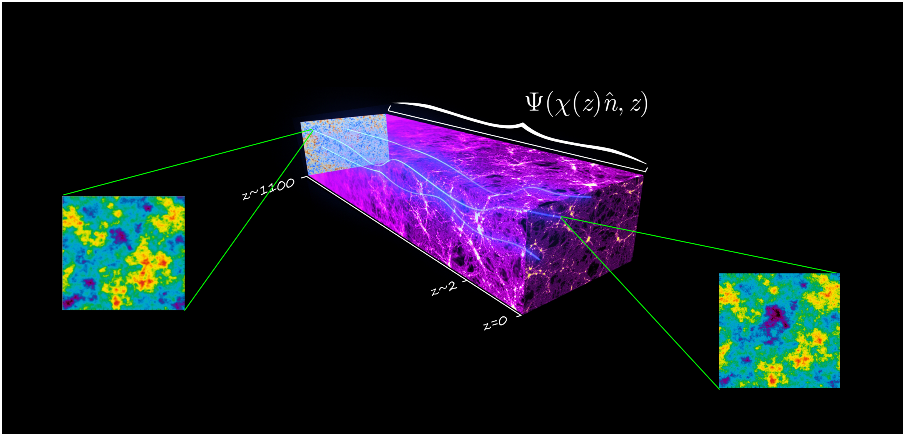


Figure: by PLANCK

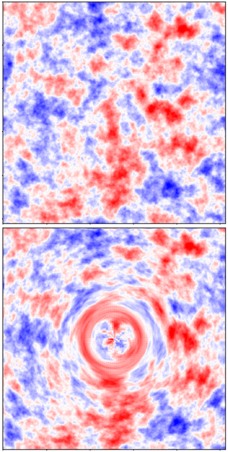


Figure: Unlensed and lensed CMB map(Wang Z.Y.,2018)

$$\tilde{\Theta}(\hat{\boldsymbol{n}}) = \Theta(\hat{\boldsymbol{n}} + \boldsymbol{\alpha})$$

Deflection Angle:

$$\boldsymbol{\alpha}(\hat{n}) = \nabla\phi(\hat{n})$$

Lensing potential:

$$\phi(\hat{n}) = -\frac{2}{c^2}\int_0^{z_*}\frac{\mathrm{d}z}{H(z)}\frac{\chi_* - \chi(z)}{\chi_*\chi(z)}\Psi(\chi(z)\hat{n}, z)$$

$$\chi(z) = \int_0^z \frac{\mathrm{d}z}{H(z)},\ \chi_* = \chi(z_*)$$

Where Ψ is Newtonian gravitational potential.

CMB lensing of polarization

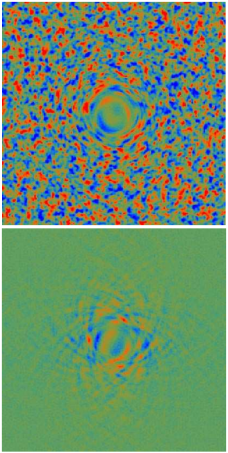


Figure: Lensed E-mode and B-mode(W.Hu,2008)

Polarization:

$$\delta \begin{bmatrix} E(\boldsymbol{k}) \\ B(\boldsymbol{k}) \end{bmatrix} = \int \frac{\mathrm{d}^2 k'}{(2\pi)^2} W(\boldsymbol{k}', \boldsymbol{k}') \; R(2\varphi_{\boldsymbol{k}'\boldsymbol{k}}) \begin{bmatrix} \tilde{E}(\boldsymbol{k}') \\ \tilde{B}(\boldsymbol{k}') \end{bmatrix}$$

Where:

$$R(2\varphi_{\boldsymbol{k}'\boldsymbol{k}}) = \begin{bmatrix} \cos 2\varphi_{\boldsymbol{k}'\boldsymbol{k}} & -\sin 2\varphi_{\boldsymbol{k}'\boldsymbol{k}} \\ \sin 2\varphi_{\boldsymbol{k}'\boldsymbol{k}} & \cos 2\varphi_{\boldsymbol{k}'\boldsymbol{k}} \end{bmatrix}$$

$$\varphi_{\boldsymbol{k}'\boldsymbol{k}} = \varphi_{\boldsymbol{k}'} - \varphi_{\boldsymbol{k}}$$

$$W(\boldsymbol{k}', \boldsymbol{k}') = -[\boldsymbol{k} \cdot (\boldsymbol{k} - \boldsymbol{k}')]\phi(\boldsymbol{k} - \boldsymbol{k}')$$

Lens will convert a part of E-mode to B-mode polarization!

Lensing convergence, which depends on the projected matter overdensity (Bartelmann & Schneider 2001)

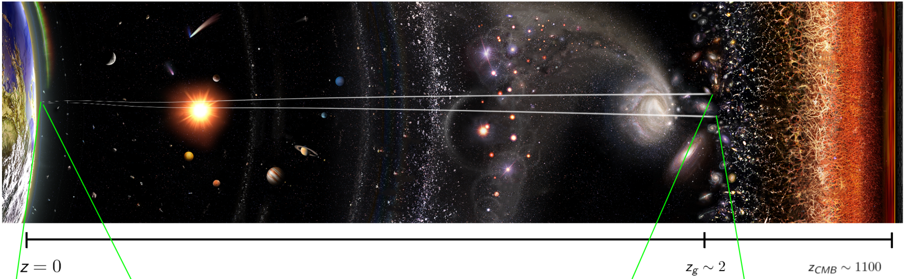
$$\kappa(\hat{n}) = -\frac{1}{2}\nabla^2\phi(\hat{n}) = \int_0^{z_*} \mathrm{d}z W^{\kappa}(z)\delta(\chi(z)\hat{n}, z)$$

$$\delta(\chi(z)\hat{n}, z) = 1 - \frac{\rho_m(\chi(z)\hat{n}, z)}{\bar{\rho}_m}$$

Where the lensing kernel W^{κ} is:

$$W^{\kappa}(z) = \frac{3\Omega_{m,0}}{2c}\frac{H_0^2}{H(z)}(1+z)\chi(z)\frac{\chi_* - \chi(z)}{\chi_*}$$

Galaxies



by CDM or ?

Overdensity:

$$g(\hat{n}) = \int_0^{z_*} dz W^{g}(z)\delta(\chi(z)\hat{n}, z)$$

Where the kernel is (Xia et al. 2009):

$$W^{g}(z) = \frac{b(z)\frac{dN}{dz}}{\int dz' \frac{dN}{dz'}} + \frac{3\Omega_m}{2c}\frac{H_0^2}{H(z)}(1+z)\chi(z)\int_z^{z_*} dz'(1-\frac{\chi(z)}{\chi(z')})(\alpha(z')-1)\frac{dN}{dz'}$$

Previous analyses indicate:

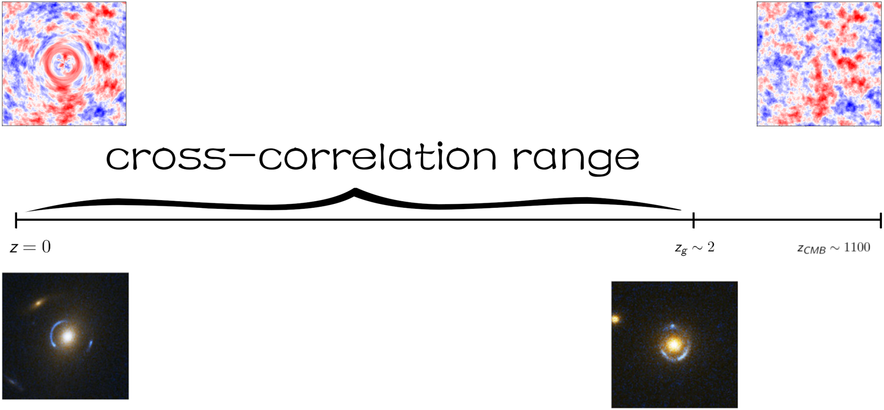
Bias(Xia et al. 2012; Cai et al. 2013):

$$b \simeq 3$$

Slope(Béthermin et al. 2012)

$$\alpha \simeq 2, Noise \propto S^{-\alpha}$$

Cross-correlation



Theoretically(Limber,1953):
Cross-correlation:

$$C_\ell^{\kappa g} = \int_0^{z_*} \frac{\mathrm{d}z}{c} \frac{H(z)}{\chi^2(z)} W^\kappa(z) W^g(z) P(k = \frac{\ell}{\chi(z)}, z)$$

Mean redshift:

$$z = \frac{\int_0^{z_*} z \frac{\mathrm{d}z}{c} \frac{H(z)}{\chi^2(z)} \chi^2(z) W^\kappa(z) W^g(z) P(k = \frac{\ell}{\chi(z)}, z)}{\int_0^{z_*} \frac{\mathrm{d}z}{c} \frac{H(z)}{\chi^2(z)} W^\kappa(z) W^g(z) P(k = \frac{\ell}{\chi(z)}, z)} \simeq 2$$

Conclusion

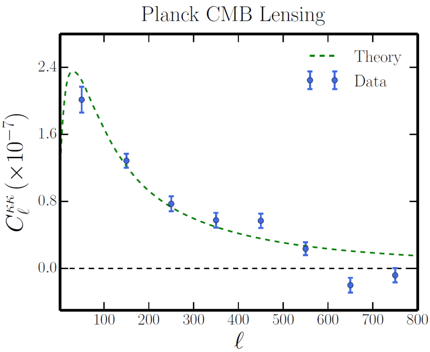


Figure: **CMB convergence autopower spectrum**

$$C_\ell^{\kappa\kappa} = \int_0^{z_*} \frac{\mathrm{d}z}{c} \frac{H(z)}{\chi^2(z)} [W^\kappa(z)]^2 P(k = \frac{\ell}{\chi(z)}, z)$$

Conclusion

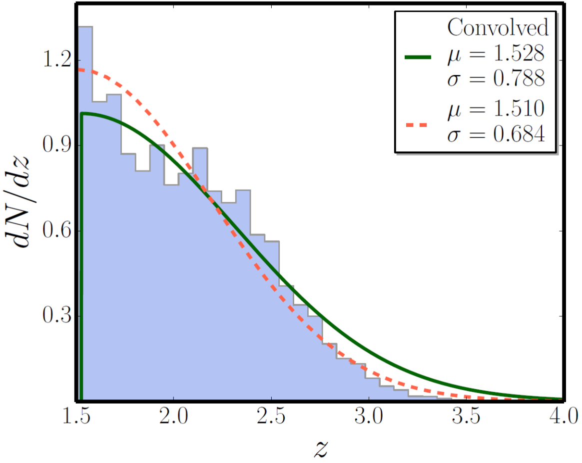


Figure: **Redshift distribution of H-ATLAS galaxies**

Conclusion

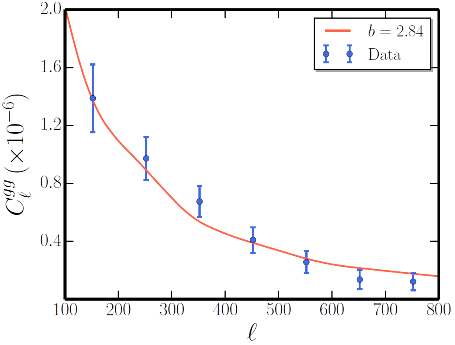


Figure: **Galaxies autopower spectrum**

$$C_\ell^{\mathrm{gg}} = \int_0^{z_*} \frac{\mathrm{d}z}{c} \frac{H(z)}{\chi^2(z)} [W^{\mathrm{g}}(z)]^2 P(k = \frac{\ell}{\chi(z)}, z)$$

Conclusion

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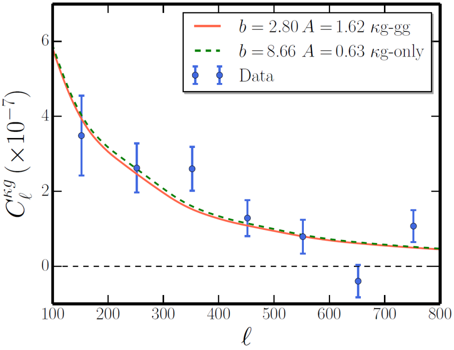

Figure: **Cross-correlation**

$$C_\ell^{\kappa g} = \int_0^{z_*} \frac{\mathrm{d}z}{c} \frac{H(z)}{\chi^2(z)} W^\kappa(z) W^g(z) P(k = \frac{\ell}{\chi(z)}, z)$$

Conclusion

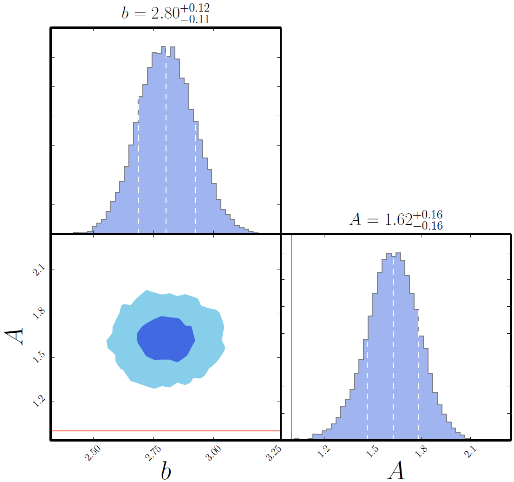

Figure: b-A plane with the 68% and 95% confidence,A is higher than expected from the standard model

Cross-correlation with *Dark Energy*

$$b(z) \quad A \;\; of \;\; C_\ell^{\kappa g} \quad H_0, H(z) \quad \Omega_m \quad \frac{dN}{dz}$$

$$\downarrow$$

$$\Omega_\Lambda$$

Appreciate your Criticism