Constraining Multiplicative Bias in CFHTLenS Shear Data

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1503.06214: JL & Hill
1601.05720: JL, Ortiz-Vazquez, & Hill

Rencontres de Moriond, Cosmology
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154 deg² Canada-France-Hawaii Telescope Lensing Survey (CFHTLenS)

CFHTLenS convergence map
[Van Waerbeke et al 2013]
Tension with CMB Temperature Anisotropy

\[ A = 0.44 \pm 0.22 \]

[MacCrann et al 2014]

[JL & Hill 2015, arxiv:1503.06214]
Source of the 50% Disagreement?

- Photo $z$ (10%)
- Intrinsic Alignments (10-15%)
- Masking of tSZ Clusters (5-10%)
- Multiplicative Bias (?)
- New Physics (maybe not..yet)
Origin of the **Multiplicative Bias** in Shear Measurements

- **Model Bias**: Mismatch between model and real galaxy shapes
- **Noise Bias**: PSF, pixelization
- **Nonlinear coupling**: Between model and noise biases

[e.g. Kacprzak et al 2014]
Weak Lensing and Galaxy Shapes
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Weak Lensing and Galaxy Shapes

Intrinsic galaxy (shape unknown) → Gravitational lensing causes a shear \( g \) → Atmosphere and telescope cause a convolution → Detectors measure a pixelated image → Image also contains noise

[ C. Heymans ]
Can CMB Lensing Help Cosmic Shear Surveys?

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(Dated: November 12, 2013)

Yes! Upcoming galaxy shear surveys have the potential to significantly improve our understanding of dark energy and neutrino mass if lensing systematics can be sufficiently controlled. The cross-correlations between the weak lensing shear, galaxy number counts from a galaxy redshift survey, and the CMB lensing convergence can be used to calibrate the shear multiplicative bias, one of the most challenging systematics in lensing surveys. These cross-correlations can significantly reduce the deleterious effects of the uncertainties in multiplicative bias.

\[
C_{\ell}^{K_{\text{CMB}}} = \frac{3}{2} \Omega_m H_0^2 \int d\eta \, b_\ell(\eta) W_f(\eta) \frac{g_{\text{CMB}}(\eta)}{a(\eta)} P \left( \frac{\ell}{d_A}, \eta \right),
\]

(4)

\[
C_{\ell}^{K_{\text{opt}} \Sigma} = m \frac{3}{2} \Omega_m H_0^2 \int d\eta \, b_\ell(\eta) W_f(\eta) \frac{g_{\text{opt}}(\eta)}{a(\eta)} P \left( \frac{\ell}{d_A}, \eta \right),
\]

(5)

\[
\frac{C_{\ell}^{K_{\text{opt}} \Sigma}}{C_{\ell}^{K_{\text{CMB}}}} = m \frac{g_{\text{opt}}(\eta)}{g_{\text{CMB}}(\eta)}
\]

(6)
\( \kappa_{\text{cmb}}, \kappa_{\text{gal}}, \) and \( \Sigma \) maps

- Planck convergence
- CFHTLenS convergence
- CFHTLenS galaxy density
Source Distributions and Lensing Kernels

\[ \frac{dn}{dz}(18 < i < 22) \]
\[ \frac{dn}{dz}(18 < i < 23) \]
\[ \frac{dn}{dz}(18 < i < 24) \]

\[ W_{\text{gal}} \]
\[ W_{\text{emb}} \]
Cross-Power Spectra

[JL, Ortiz-Vazquez, & Hill, 2016]
$C_{\ell}^{\kappa_{\text{CMB}} \Sigma} = \frac{3}{2} \Omega_m H_0^2 \int d\eta b_{\ell}(\eta) W_f(\eta) \frac{g_{\text{CMB}}(\eta)}{a(\eta)} P \left( \frac{\ell}{d_A}, \eta \right)$, \hspace{1cm} (4)

$C_{\ell}^{\kappa_{\text{opt}} \Sigma} = m \frac{3}{2} \Omega_m H_0^2 \int d\eta b_{\ell}(\eta) W_f(\eta) \frac{g_{\text{opt}}(\eta)}{a(\eta)} P \left( \frac{\ell}{d_A}, \eta \right)$, \hspace{1cm} (5)

$\frac{C_{\ell}^{\kappa_{\text{opt}} \Sigma}}{C_{\ell}^{\kappa_{\text{CMB}} \Sigma}} = m \frac{g_{\text{opt}}(\eta)}{g_{\text{CMB}}(\eta)}$ \hspace{1cm} (6)

$18 < i < 22$
Constraints on \( b \) and \( m \)

- A 2–4 \( \sigma \) evidence for the multiplicative bias (\( m < 1 \)) in our deepest galaxy sample.

- Can potentially explain the disagreement between CFHTLenS shear 2-point function and Planck temperature measurements (\( m \sim 0.9 \) needed).

- Covariance dominated by the CMB lensing map noise at present.

[ J.L, Ortiz-Vazquez, & Hill 2016 ]