A direct measurement of tomographic lensing power spectra from CFHTLenS

(in press at MNRAS; arXiv1509.04071)

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I. Introduction
Cosmological model

- Dark Matter: 26.8%
- Dark Energy: 68.2%
- Baryons: 4.9%

Springel et al. (2006)
Lensing statistic:

shear-shear
(a.k.a. cosmic shear)
Weak lensing: Future

- **CFHTLenS**
  - $10^2$ deg$^2$
  - 17 gals/arcmin$^2$
  - $z_m = 0.75$

- **RCSLenS**
  - 6 gals/arcmin$^2$
  - $z_m = 0.60$

- **KiDS**
  - $10^3$ deg$^2$
  - 9 gals/arcmin$^2$
  - $z_m = 0.70$

- **HSC**
  - 20 gals/arcmin$^2$
  - $z_m = 1.00$

- **DES**
  - 8 gals/arcmin$^2$
  - $z_m = 0.65$

- **Euclid**
  - $10^4$ deg$^2$
  - 30 gals/arcmin$^2$
  - $z_m = 0.90$

- **LSST**
  - 31 gals/arcmin$^2$
  - $Z_m = 1.00$

- **completed**
- **ongoing**
- **> 2020**
Weak Lensing: Challenges

1) Accurate photometric redshifts

2) Shape noise:

“The bigger (deeper) the survey the smaller the uncertainties!”

3) Blending (!)
II. Cosmic Shear
Lensing of LSS:

Theory:

\[ C_{\mu \nu}^{EE}(\ell) = \frac{9 \Omega_m^2 H_0^4}{4 c^4} \int_0^{\chi_H} d\chi \frac{g_\mu(\chi) g_\nu(\chi)}{a^2(\chi)} P_\delta \left( k = \frac{\ell}{f_K(\chi)} ; \chi \right) \]

measurements:

correlation functions \iff power spectra

“geometry”

“physics”
Baryons & neutrinos:

AGN feedback from OWLS after Harnois-Déraps et al. (2015)

3 degenerate, massive neutrinos with $\Sigma m_\nu = 0.18$ eV

integration over lensing kernel

AGN feedback from OWLS after Harnois-Déraps et al. (2015)

3 degenerate, massive neutrinos with $\Sigma m_\nu = 0.18$ eV
The CFHTLenS case:

\[ \sim 154 \text{ deg}^2 \sim 115 \text{ deg}^2 \]

\[ n_{\text{gal}} = 17 \text{ gals/arcmin}^2 \]

two redshift slices:

\[ z_1: 0.50 < z \leq 0.85 \]
\[ z_2: 0.85 < z \leq 1.30 \]

minimize intrinsic alignments

!!! PUBLIC data !!!

Erben et al. (2012)
Results: Multipole Space

quadratic estimator method (Hu & White 2001) expanded to include photometric redshift bins

WL power spectra from CFHTLenS (W1, W2, W3 & W4 combined with inverse variance weights)

\[ z_1: 0.5 < z \leq 0.85 \]
\[ z_2: 0.85 < z \leq 1.3 \]

FK+ (in press)
Cosmological inference:

![Graph showing the relationship between $\Omega_m$ and $\sigma_8$ with different models and constraints.]

- $\Lambda$CDM
- $\Lambda$CDM + all
- Planck 2015

FK+ (in press)
Cosmological inference:

Model: $\Lambda$CDM+all

Total mass of 3 massive, degenerate neutrinos
Cosmological inference:

Which model describes the data the best?
Evidences:


<table>
<thead>
<tr>
<th>Model</th>
<th>ln $Z$</th>
<th>$2 \ln K$ ($K \equiv Z_i/Z_{\Lambda CDM}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Lambda$CDM</td>
<td>$-40.96 \pm 0.06$</td>
<td>0</td>
</tr>
<tr>
<td>$\Lambda$CDMa</td>
<td>$-41.07 \pm 0.06$</td>
<td>-0.22</td>
</tr>
<tr>
<td>$\Lambda$CDM + $\nu$</td>
<td>$-41.63 \pm 0.07$</td>
<td>-1.34</td>
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<tr>
<td>$\Lambda$CDMa + $\nu$</td>
<td>$-41.83 \pm 0.07$</td>
<td>-1.74</td>
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<tr>
<td>$\Lambda$CDM + $A_{bary}$</td>
<td>$-41.66 \pm 0.06$</td>
<td>-1.40</td>
</tr>
<tr>
<td>$\Lambda$CDM + $\nu$ + $A_{bary}$</td>
<td>$-42.48 \pm 0.07$</td>
<td>-3.04</td>
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<tr>
<td>$\Lambda$CDM + $\Delta z_{\mu}$</td>
<td>$-40.75 \pm 0.07$</td>
<td>0.42</td>
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<tr>
<td>$\Lambda$CDM + all</td>
<td>$-42.19 \pm 0.07$</td>
<td>-2.46</td>
</tr>
</tbody>
</table>

FK+ (in press)
Cosmological inference:

Degeneracy broken: $\Omega_m = 0.300 \pm 0.011$, $\sigma_8 = 0.818 \pm 0.013$
III. Conclusions
A direct extraction of the lensing power spectrum is a “cleaner” way to compare data with theory.

The power spectrum results show overall consistency with previous results based on correlation-functions.

Ongoing and future lensing surveys have the potential to constrain distinct features in multipole space such as left by massive neutrinos or baryon feedback with high precision.