Preliminary Results on CFHTLenS Peak Counts and Magnification Bias on Peak Counts and Power Spectrum

Jia Liu (Columbia University)
Advisor: Zoltán Haiman

Collaborators: A. Petri (Columbia), L. Hui (Columbia), J. Kratochvil (KwaZulu-Natal), M. May (BNL)
Dark Energy Probes

H(z)

- $d_L(z)$
  - Supernova
- $d_A(z)$
  - BAO
- V(z)
  - Clusters
  - Weak Lensing
  - Strong Lensing

NCSA, Kravtsov, Klypin, Kravtsov

Growth of structure

Clusters
Weak Lensing
P(k,z)

$z = 30$

$z = 0$
Non-Gaussian Convergence Field

\[ \kappa(\vec{\theta}) = \frac{1}{2} \nabla^2 \psi(\vec{\theta}) \]

Yang et al. 2011
High peaks
Massive halos

Low peaks
Constellations of several small halos, or aligned filaments (?)
Minkowski Functionals

$V_0(\nu) \quad$ area above threshold

$V_1(\nu) \quad$ length of boundary

$V_2(\nu) \quad$ # of connected region – # of holes
Cosmological Constraints

➔ larger $\Omega_m$ & $\sigma_8$ increase low/high peaks, decrease medium peaks - degeneracy in these 2 parameters

➔ Effect of varying $w$ is smaller, but less degenerate
Cosmological Constraints

(Petri el al, in prep)
Step 1: download the data
CFHTLenS fields
Erben et al 2013

156 deg$^2$, $i_{AB} \leq 24.5$
$13 \times 3.5^2 \text{ deg}^2$

simulation subfields
N-body Simulation & Ray-tracing

<table>
<thead>
<tr>
<th></th>
<th>$\Omega_m$</th>
<th>$w$</th>
<th>$\sigma_8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiducial</td>
<td>0.26</td>
<td>-1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>High $\Omega_m$</td>
<td>0.29</td>
<td>-1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>High $w$</td>
<td>0.26</td>
<td>-0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>High $\sigma_8$</td>
<td>0.26</td>
<td>-1.0</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Shear & convergence

$$\hat{\kappa}(s) = \frac{1}{2} \left( \frac{k_1^2 - k_2^2}{k_1^2 + k_2^2} \right) \hat{\gamma}_1(s) + \frac{k_1 k_2}{k_1^2 + k_2^2} \hat{\gamma}_2(s)$$
Convergence Maps

CFHTLenS

Simulation (with galaxy noise)
CFHTLenS
Peak Counts
Building Cosmology Model

\[ N_{\text{theory},i}(\Omega_m, w, \sigma_8) = N_i(\Omega_m^*, w^*, \sigma_8^*) + \frac{\partial N_i}{\partial \Omega_m} \Delta \Omega_m + \frac{\partial N_i}{\partial w} \Delta w + \frac{\partial N_i}{\partial \sigma_8} \Delta \sigma_8 \]

\[ \chi^2(\Omega_m, w, \sigma_8) = \Delta N_i C_{ij}^{-1} \Delta N_j \]

\[ \Delta N = N_{\text{obs}} - N_{\text{theory}} \]
Photo-z Uncertainty

Shirasaki & Yoshida 2013

\[ 0.2 < z < 1.3 \]

- peak of PDF \((<z> = 0.69)\)
- sum of PDF \((<z> = 0.75)\)

\[ \Delta w = 0.02 \]
\((\approx 1 \sigma_w \text{ LSST})\)

- peak z
- random draw z
(Using 6 subfields)
Magnification Bias (MB)

**Boost density** In a magnitude-limited survey, some galaxies slightly fainter than the observation limit will now be magnified and included in the sample.

**Dilute density** A region on the sky appears to be larger due to the bending of light.

(PhysRevD.89.023515)
Self-Calibrate MB using Peak Counts and Power Spectrum

For LSST, $\Omega_m$, $w$ and $\sigma_8$ are biased by many $\sigma$.

The parameters are biased in different directions in the $(\Omega_m, w, \sigma_8)$ parameter space for the power spectrum and peak counts. Therefore, using both statistics, we can better correct MB.
Conclusions

➔ Non-Gaussian weak lensing statistics (peak counts, minkowski functionals, moments) are complementary to the power spectrum;

➔ Photo-z error has little impact on peak counts at surveys of \( \ll 10,000 \, \text{deg}^2 \) size;

➔ In progress: cosmological parameters using peak counts - stay tuned for full analysis!