The Impact of Spectroscopic Incompleteness for Weak Lensing Surveys

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with Chihway Chang (KICP), Soniya Samani (QMU, Oxford)
and DES
Cosmology is done*

* Not really.

- $\Lambda$CDM model is an exceptional fit to measurements of the CMB!
- But tells us little about Dark Energy, if it evolves with time.
- Model is phenomenological: we don’t know what dark matter or dark energy are!
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- $\Lambda$CDM model is an exceptional fit to measurements of the CMB!
- But tells us little about Dark Energy, if it evolves with time.
- Model is phenomenological: we don’t know what dark matter or dark energy are!
- Late time probes of cosmological parameters agree marginally with Planck $\Lambda$CDM. - or not!
- Tantalising possibility of missing physics, but a lot of hard work before we get an answer.
- $\rightarrow$ This is why we are spending so much effort on Euclid.

Hildebrandt et al. (2019)

Dark Energy Survey et al. (2018)
Cosmology from cosmic shear

Two ingredients:
1) Shear correlation function
2) Redshift distribution(s)

Bonnett, Troxel, Hartley, Amara & DES (2016)
The Dark Energy Survey – Y1 analysis

Wide-Field Survey (c. 5000 sq deg):
- 90 sec exposures in griz;
- 45 sec exposures in Y

Typically 2 survey tilings/filter/year

Supernova Survey (c. 30 sq deg):
- 150-200 sec exp’s in griz (shallow)
- 200-400 sec exp’s in griz (deep)

Many repeat observations

Overlap with the South Pole Telescope Survey (SPT)

Credit: A. Merson

Redshifts calibrated to $\Delta z / (1+z) \sim 0.015$
Direct calibration of redshift distributions

Based on Lima+ (2008): reweight the the galaxies in the spectroscopic sample so that their photometric (color, mag) distribution matches the target sample → the redshift distribution of the reweighted spectroscopic sample will also match the true redshift distribution of the target sample.
Direct calibration of redshift distributions

- Spectroscopic object
- Target WL sample object
Assumptions in the Lima et al. method

- The spectroscopic redshifts of the sample being weighted are all correct.
- The uncertainties in the photometry of the spectroscopic sample are representative of the target sample.
- At any given locale in photometric space, the available spectroscopic redshifts are equivalent to a random draw from the true redshift.

Goal of this work:

- Quantitatively examine the validity of the last point above.
- Justify the choice of not using this method for redshift calibration in DES Y1.
- Figure out what this implies for future DES analyses and Euclid / LSST.
Spectroscopic incompleteness

The underlying assumption of the previous statement is that all the selections that is involved in compiling the spectroscopic sample can be recovered using the colors available to the target sample.

\[
\text{Spectroscopic incompleteness} = 4 \text{ numbers (DES Y1)} \\
4 \text{ numbers (HSC)} \\
9 \text{ numbers (KV-450)}
\]
Obvious examples where this is not true

- **PRIMUS**: redshifts obtained by fitting low resolution spectra and any matched photometry to an empirical library of spectra, hard cut at $z=1.2$
- **VIPERS**: selection uses $u$-band, which is not accessible by DES
- **DEEP2**: selection uses $B$-band, which is not accessible by DES
Less obvious examples

\[ i=22, \ z=0.77 \]

\[ i=22.3, \ z=1.19 \]

Typically, Flag\( \geq 3 \) is used to select reliable redshifts in spectroscopic samples, where the Flags are given by experienced redshifters that use a combination of features in the spectra to determine the Flag and redshift.
Steps

- Simulate spectra coming from the 4 main VIMOS samples used in DES Y1: VVDS Deep/Wide, VIPERS, zCOSMOS [Poisson noise, otherwise pretty idealized].
- Recruit DES/OzDES colleagues to redshift the spectra and assign Flags.
- Use random forest (RF) to enlarge sample.
- Apply Lima et al. method where target sample is the DES Y1 WL sample.
- Evaluate the resulting bias in the mean redshift for each tomographic bin as a function of minimum Flag used for spec sample.
Obtaining confidence flags

Random Forest features:

<table>
<thead>
<tr>
<th>Wavelength (Å)</th>
<th>Feature</th>
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<tbody>
<tr>
<td>1215.7</td>
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<tr>
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<td>NV</td>
</tr>
<tr>
<td>1303.0</td>
<td>OI</td>
</tr>
<tr>
<td>1334.5</td>
<td>CII</td>
</tr>
<tr>
<td>1397.0</td>
<td>SiIV1393+OIV1402</td>
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<tr>
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<tr>
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<td>HeII</td>
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<tr>
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<td>CIII</td>
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<tr>
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<td>NIII</td>
</tr>
<tr>
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<td>FeII</td>
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<tr>
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<tr>
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<td>[OIIIb]</td>
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<td>[SII]6717.0+6731.3</td>
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</tbody>
</table>
Results

Hartley et al. (in prep)

NB: more bands = better, but need to check the exact level
Results

Hartley et al. (in prep)

Preliminary

Weighted in griz
Also in agreement with comparisons between incomplete spectroscopic samples and 8-band photometric redshifts.
Potential mitigation approach?

- Use lower Flags
- Remove uncertain SOM cells
- Calibrate via simulations

Neither seem super promising at the first pass… but clearly more work needs to go into this.
Summary

- Our spectroscopic samples are constructed via selections that may not be recoverable via color cuts available to the photometric surveys.

- Using simulations, we examined the effect of such spectroscopic incompleteness on the resulting redshift estimate for a DES Y1-like sample.

- We find that for DES Y1, direct calibration introduces biases on the mean redshift at a level that exceeds the other calibration methods.

- Going forward, more work needs to go into understanding the selection in our spectroscopic selection, not only for direct calibration. This needs to be taken into account in on-going spectroscopic targetting (e.g. C3R2), but we are well-placed to do so in Euclid.