BAO at $z = 0.72$ in the eBOSS LRG sample

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53ème Rencontres de Moriond
• The LRG sample

• Improvements in the data reduction

• BAO measurement
The LRG sample
Target selection

Prakash++2015,2016
Lang++2014

Magnitude cuts

19.9 < Sloan $i_{\text{model}}$ < 21.8
19.95 < Sloan $z_{\text{model}}$
Sloan $z_{\text{fiber2}}$ < 21.7
$W1_{\text{AB}}$ < 20.3

CMASS:
17.5 < Sloan $i_{\text{cmodel}}$ < 19.9
Sloan $i_{\text{fiber2}}$ < 21.5

Color cuts

$r - i > 0.98$
$i - z > 0.625$
$r - W1 > 2(r - i)$

model: integrated flux over all object model
fiber2: integrated flux in central 2'' aperture
Target selection

Prakash++2015, 2016
Lang++2014

Pilot spectroscopic survey
SEQUELS (Dawson++2016)
followed by visual inspection

- 8.8% stellar contamination
- 6.7 to 11.2% of poor S/N spectra
- 68.3% LRGs in good redshift range

| Redshift Distribution of eBOSS LRGs, Based upon Results for a Sample of 2557 Visually Inspected Spectra |
|-----------------------------------------------|----------------|--------------------|
| LRGs z_conf > 0                              | LRGs z_conf > 1 |
| Poor spectra                                | 4.0             | 6.7                |
| Stellar                                     | 5.3             | 5.3                |
| Galaxy                                      | N/A             | N/A                |
| 0.0 < z < 0.5                               | 0.6             | 0.6                |
| 0.5 < z < 0.6                               | 6.2             | 5.9                |
| 0.6 < z < 0.7                               | 15.2            | 14.8               |
| 0.7 < z < 0.8                               | 15.3            | 14.7               |
| 0.8 < z < 0.9                               | 9.4             | 8.7                |
| 0.9 < z < 1.0                               | 3.2             | 2.7                |
| 1.0 < z < 1.2                               | 0.6             | 0.5                |
| Targets                                     | 60              | 60                 |
| Total Tracers                               | 43.1            | 41.0               |

Cosmological Sample

units of deg^2
Example LRG spectra

From Prakash++2016
Improvements in data reduction

- extraction
- flux calibration
- redshift fitter
Extraction

New unbiased extraction yields near zero sky residuals
(Bautista++2017)
Flux Calibration

More accurate spectroscopic flux calibration accounting for atmospheric differential refraction in individual exposures

Spectro vs photometric magnitude residuals (from Jensen++2016)
Redshift Fitting

Spectral classification using physically motivated templates instead of PCA eigenvectors as in Bolton++2012

Redmonster by Hutchinson++2016

https://github.com/timahutchinson/redmonster

3 galaxy $X^2$ scan examples

No statistically significant single best redshift value:

Redshift failures :(

(from Hutchinson++2016)
SDSS Data Release 14

http://dr14.sdss.org/

- First and second year of eBOSS raw and reduced data up to May 11th 2016
- Also includes reprocessing of all BOSS data
- Includes all improvements in reduction just mentioned
BAO Measurement

Bautista et al. 2018
https://github.com/julianbautista/eboss_clustering
Footprint and $n(z)$

Combined with BOSS CMASS galaxies $z > 0.6$
Mock Catalogs

- 1000 realizations using Quick Particle Mesh technique (White++2013)
- HOD model to small-scale clustering (Zhai++2016)
- reconstruction technique to sharpen BAO peak (Burden++2015, Vargas-Magaña++2017)
Systematics

- correcting for fluctuations caused by photometry (Ross et al. 2016)
- simultaneous linear fit of 7 potential systematics (Prakash et al. 2016)

red = before correction
blue = after correction
Systematics

- correcting for fluctuations caused by photometry (Ross et al. 2016)
- simultaneous linear fit of 7 potential systematics (Prakash et al. 2016)

red = before correction
blue = after correction
Redshift Failures

- correcting for fluctuations caused by redshift failures
- spectroscopic efficiency = $\frac{N_{\text{gal}}}{N_{\text{fail}} + N_{\text{gal}}}$

Efficiency as a function of position of optical fiber in focal plane

Efficiency as a function of spectrograph S/N

To account for this effect, we ‘add failures’ into the random catalog.
Similar procedure found in Blake++2010
Redshift Failures

- test of two correction methods for failures using mock catalogs
- sub-sampling is better than nearest-neighbor correction technique used in previous CMASS measurements (Alam et al. 2016)
- amplitude of mis-estimation is proportional to average failure rate
BAO Fitting

Isotropic BAO fit: \( D_V(z_{\text{eff}} = 0.72) = 2353^{+63}_{-61} (r_d/r_{d,\text{fid}}) \text{Mpc} \)

Sample not large enough yet for anisotropic constraints
BAO Distance with eBOSS LRGs

Isotropic BAO fit: \[ D_V (z_{\text{eff}} = 0.72) = 2353^{+63}_{-61} (\frac{r_d}{r_{d,\text{fid}}}) \text{Mpc} \]

Back of the envelope correlation between this measurement and CMASS measurement yields 16%.
Growth rate from eBOSS LRGs

Vargas-Magaña, Icaza, Fromenteau ++(in prep)

Preliminary
Conclusion

- BOSS+eBOSS is currently the largest spectroscopic survey
- 2.6% isotropic BAO with LRGs at z=0.72 with two years of data
- End of survey and final results by mid 2019. We expect ~ 1.5% error on BAO from LRGs only.
- Optimal multi-tracer analysis with eBOSS LRG+ELG+QSO+CMASS in overlapping areas.
- Dark energy is a cosmological constant? Varies with time?
- Bonus cosmology: neutrino masses, curvature, non-Gaussianity, etc…