Redshift-space distortion analysis from the DR14 eBOSS quasar sample in Fourier space

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Statistical challenges for large-scale structure in the era of LSST
Oxford, 20th April 2018

Based on HGM et al. 2018, arXiv:1801.02689
BAO & RSD Papers on DR14Q

This talk

- Gil-Marín et al. 18 (RSD in Fourier space)
- Hou et al. 18 (RSD in config. Space)
- Zarrouk et al. 18 (RSD in conf. space)
- Ruggeri et al. 18 (z-weighting RSD in Fourier Space)
- Zhao et al. 18 (z-weighting RSD in Fourier Space)
- Ata et al. 18 (BAO isotropic, Fourier & conf. space)
- Wang et al. 18 (z-weighting BAO in Fourier space)
- Zhu et al. 18 (z-weighting BAO in conf. space)

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Hector Gil-Marín
eBOSS in a nutshell

- Part of SDSS-IV collaboration
- Spectroscopic survey: $\sigma_z \sim 0.001$
- Apache Point Telescope 2.5m
- 2014 - 2019 observing LRGs, ELGs, quasars + Ly$\alpha$
- 1000 fibres per plate ($\sim 7$ deg$^2$)
- 1000 EZ & 400 QPM mocks for covariances

- $0.8 < z < 2.2$
- Wide redshift range
- 148,659 quasars
- Low density of tracers: $2 \times 10^{-5}$ h/Mpc
- Low density variation

2112.9 deg$^2$
Three types of redshift estimates

- The $z_{\text{PL}}$ automated classification: Template-based PCA fit to CIV-line
- The $z_{\text{PCA}}$ automated classification: Template-based PCA fit to MgII-line
- The $z_{\text{MgII}}$ automated classification: Location of the MgII-line peak (when present).
- **Standard redshift estimate $z_{\text{fid}}$:** Any of the above options depending on the particular object, which provides the **lowest rate of catastrophic failures**.

Credit: Vanden Berk et al. 2001
Potential observational Systematics

- **Redshift Failures:**  
  1. Weight the nearest neighbour (NN), use in BOSS analysis.  
  2. Weight all observed galaxies by their position in the plate,

\[ w_{spec}(x_{foc}, y_{foc}) \sim \frac{1}{P_{success}(x_{foc}, y_{foc})} \]

- **Collision Pairs:** Traditional nearest neighbour weighting (NN)

Imprint such effects on the mocks and check how these correction schemes perform

Redshift efficiency pattern

Fibres corresponding to edges of the spectrograph

Zarrouk et al. 18
Potential observational Systematics

Monopole

- Six lines of text explaining different corrections:
  - True signal (systematic effect not applied)
  - Corrected: redshift failures (focal weight) + close pairs (NN)
  - Corrected: redshift failures (NN) + close pairs (NN)
  - Corrected: redshift failures (focal weight) [close pairs not applied]

Quadrupole
Potential modelling Systematics

- Use OuterRim N-body simulation at z=1.43 (Habib et al 2016) with different HOD prescriptions & w/ or wo/ (Gaussian) redshift smearing.

HOD of quasars

<table>
<thead>
<tr>
<th>Satellite Fraction</th>
<th>no sys?</th>
<th>problems?</th>
</tr>
</thead>
<tbody>
<tr>
<td>13%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Model: 2-loop RPT + TNS @ z=1.43, 0.02<k[h/Mpc]<0.30

\[
\begin{align*}
\Delta f, \alpha_{\text{para}}, \alpha_{\text{perp}}, b_1\sigma_8, b_2\sigma_8, \sigma_{\text{fog}}, A_{\text{noise}}
\end{align*}
\]

<table>
<thead>
<tr>
<th></th>
<th>(\sigma_{\text{obs}} \times 10^2)</th>
<th>(\sigma_{\text{mod}} \times 10^2)</th>
<th>(\sigma_{\text{systot}}^2 \times 10^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(f\sigma_8)</td>
<td>+2.74</td>
<td>-2.91</td>
<td>1.598</td>
</tr>
<tr>
<td>(\alpha_</td>
<td></td>
<td>)</td>
<td>-2.12</td>
</tr>
<tr>
<td>(\alpha_\perp)</td>
<td>+1.36</td>
<td>-2.35</td>
<td>0.737</td>
</tr>
</tbody>
</table>

Take highest deviation from obs & mod add in quadrature both ‘obs’ and ‘sys’ errors

... but not clear if the overall measurement would be shifted
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Comparing data with mocks

- Data looks like a typical realisation wrt the mocks
- Redshift estimate does not affect the best-fitting value significantly
- However, does affect the tails (errors) of the distribution

-Mocks as pipeline validation
- Potential systematic tests
- Unfortunately, mocks do not have spectra
Consistency results on the data

Test the effect of adding/removing the hexadecapole
Test the effect of redshift estimates on the cosmological parameters

Hexadecapole helps to break $H(z)$ vs. $\sigma_8$ and $D_A$ vs $H$ degeneracies

ZPCA larger tails
Split the $0.8 < z < 2.2$ in 3 overlapping $z$-bins

- We individually fit the 3 redshift bins
- The covariance among parameters is computed through the EZmocks

**lowz** $0.8 < z < 1.5$
**midz** $1.2 < z < 1.8$
**highz** $1.5 < z < 2.2$
Split the 0.8<z<2.2 in 3 overlapping z-bins

- We individually fit the 3 redshift bins
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Cosmological Results

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Test of flatness

$\Omega_k = -0.007 \pm 0.030$
$\Omega_m = 0.3094 \pm 0.0078$
$\Omega_\Lambda = 0.697 \pm 0.034$
Consensus with other ‘classical’ analyses

- Consensus among ‘classical’ analysis
- All uses 3 first non-null multipoles
- Only statistical errors included
- Bias models different
- Same prediction for cosmological parameters
- So far, no consensus values (alphabetical paper)

Excellent agreement among cosmological parameters
Consensus with redshift-weighted analyses

\[
\frac{f\sigma_8(z)}{[f\sigma_8(z)]_{\text{fid}}} = p_0 \left[ 1 + p_1 x(z) + p_2 x^2(z) + \ldots \right]
\]

Find optimal weights, \( p_i \)

Ruggeri et al. 2018 arxiv:1801.02891
Zhao et al. 2018 arxiv:1801.03043
**Correlation factor** $\rho = 0.97$

**3σ detection**

**In good agreement with Planck+GR**

**$D_V(z=1.52)=3843 \pm 147$ Mpc (3.8%)**

**$\chi^2=6.2/13$ for $\xi(R)$ and 27.7/33 for $P(k)$**

*Ata et al. 2017 arXiv:1705.06373*
Conclusions

- **DR14Q data.** RSD & iso-BAO analyses completed. Measurements on $D_A$, $H$ and $f_8$ at $z_{	ext{eff}}=1.52$ for the first time.
- Some remaining systematics on RSD to be corrected. So far sub-dominant wrt the statistics.
- Results in agreement with the forecasted errors by Zhao et al. 2014.
- Non-consensus results for DR14Q, but different groups present excellent agreement.

Key dates on eBOSS

- June ’17: BAO DR14Q
- January ’18: BAO DR14L
- January ’18: RSD DR14Q
- ~July ’18: RSD DR14L
- ~December ’18: BAO & RSD DR16E
- ~Fall ’19: Final DR16 BAO-RSD LRG-ELG-quasar+Lya

stay tuned!
Backup slides
NGC vs SGC

DR14Q 0.8<z<2.2

NGC
\[ \chi^2 = \frac{65}{84-7} \]
\[ \chi^2_{P0} = \frac{20}{28-7} \]
\[ \chi^2_{P2} = \frac{22}{28-6} \]
\[ \chi^2_{P4} = \frac{25}{28-4} \]

SGC
\[ \chi^2 = \frac{77}{84-7} \]
\[ \chi^2_{P0} = \frac{26}{28-7} \]
\[ \chi^2_{P2} = \frac{24}{28-6} \]
\[ \chi^2_{P4} = \frac{28}{28-4} \]
Consistency results on the data

We re-analyze the data using different prescriptions (bin position/size, sample, etc., and study how the cosmological parameters change

- QPM-choice shifts $0.67\sigma$ the $b_1\sigma_8$ and also wrt the ‘std’ case.
- 14% of the mocks present such behaviour
- It is expected that if we look at several properties, at least one of them deviate $\sim 1\sigma$
Consistency results on the data

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$z_{PCA}$ larger tails
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Test on Mocks

- 1000 mocks used to,
  1. Compute the covariance matrix of the data
  2. Test the BAO pipeline and compare it to the data
- Selection function on P(k) → extra damping on BAO

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Split the $0.8<z<2.2$ in 3 overlapping $z$-bins

- We individually fit the 3 redshift bins
- The covariance among parameters is computed through the ez-mocks

- higher Kaiser boost at high $z$
- higher damping at high $z$
- Non-understood outliers on midz

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**DR14Q Monopole**

- lowz $0.8<z<1.5$
- midz $1.2<z<1.8$
- highz $1.5<z<2.2$

**DR14Q Quadrupole**

- $\chi^2_{MgII} = 103/(84-7)$
- $\chi^2_{PCA} = 107/(84-7)$
- $\chi^2 = 122/(84-7)$ (highest mock 107)

**DR14Q Hexadecapole**

- $2\sigma$ in NGC
- $2.6\sigma$ in SGC

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