

Cosmological Constraints from the Clustering of the Sloan Digital Sky Survey DR7 Luminous Red Galaxies (arXiv:0907.1659)

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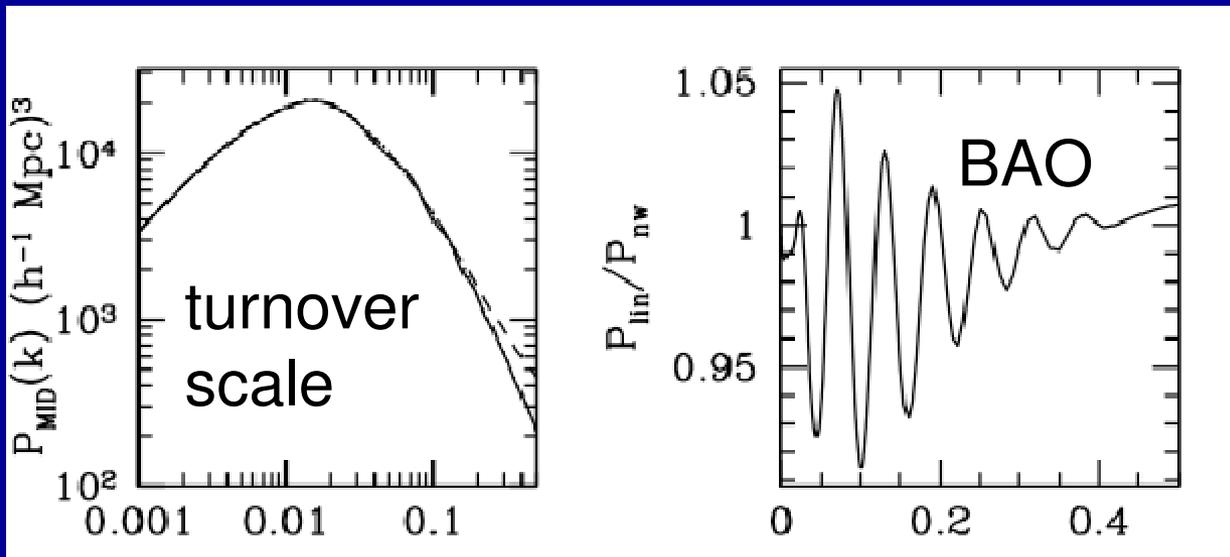
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D. Spergel, R. Skibba, SDSS TEAM

Outline

- Galaxy Power Spectrum: Lightning Review
- DR7 advance: reconstructing the halo density field
- Cosmological Constraints
- What are the gains from improved galaxy power spectrum modeling?

Measuring $P_{\text{gal}}(k)$: Motivation

- WMAP5 almost fixes* the expected $P_{\text{lin}}(k)$ in Mpc^{-1} through $\Omega_c h^2$ (6%) and $\Omega_b h^2$ (3%), independent of θ_{CMB}



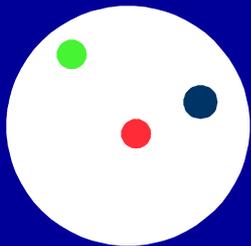
* ignoring the effect of massive neutrinos, fixing $N_{\text{rel}} = 3.046$

k ($h \text{Mpc}^{-1}$)

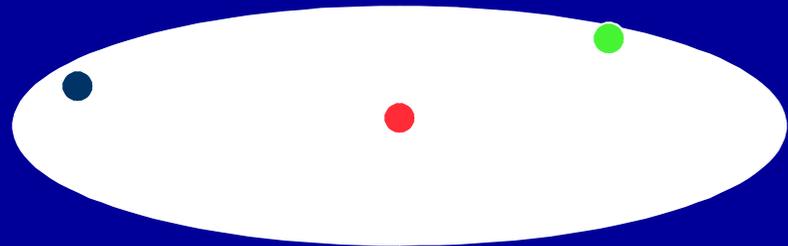
Challenges

- density field δ goes nonlinear
- uncertainty in the mapping between the galaxy and matter density fields
- Galaxy positions observed in redshift space

“Finger-of-God” (FOG)



Real space



Redshift space

z

Luminous Red Galaxies

- $n_P \sim 1$ to probe largest effective volume
 - Occupy massive halos \longrightarrow large FOG features
 - Shot noise correction important

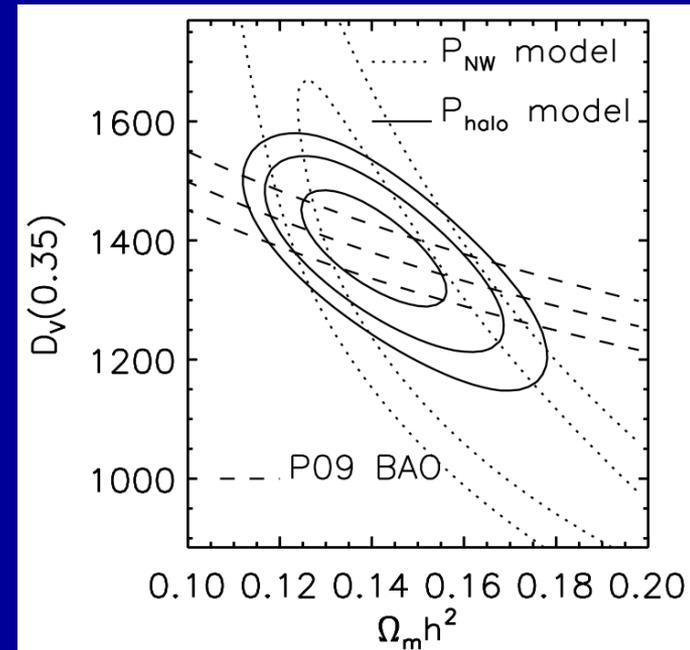
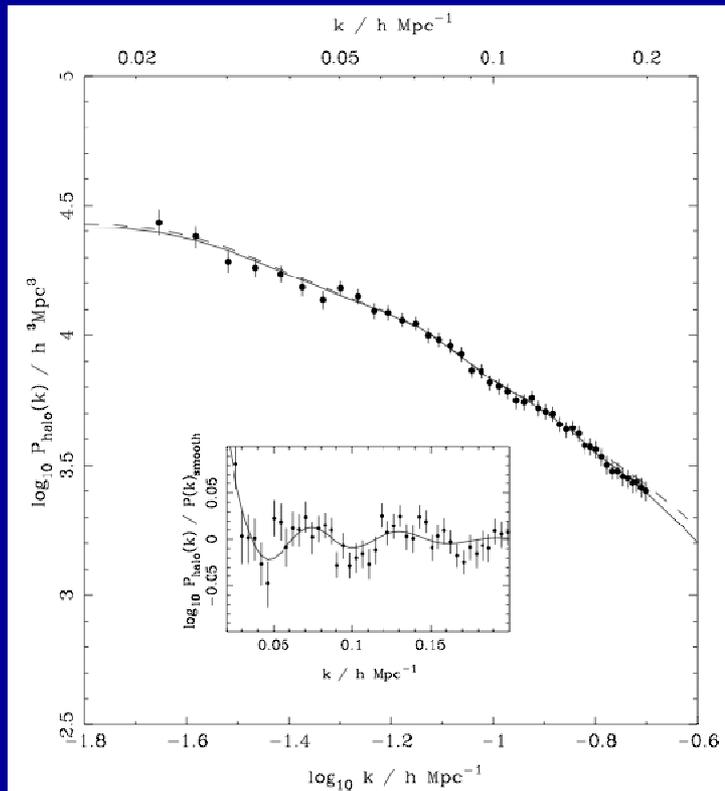
WHAT'S NEW

- n small \rightarrow find “one-halo” groups with high fidelity
 - Provides observational constraint on FOGs and “one-halo” excess shot noise
- NEW METHOD TO RECONSTRUCT HALO DENSITY FIELD
 - Better tracer of underlying matter $P(k)$
 - Replace heuristic nonlinear model (Tegmark et al. 2006 DR5) with cosmology-dependent, nonlinear model calibrated on accurate mock catalogs and with better understood, smaller modeling systematics
 - Increase $k_{\max} = 0.2 \text{ h/Mpc}$; 8x more modes!

$P_{\text{halo}}(k)$ Results

- Constrains turnover ($\Omega_m h^2 D_V$) and BAO scale (r_s/D_V)

$$D_V(z) = \left[(1+z)^2 D_A(z)^2 \frac{cz}{H(z)} \right]^{1/3}$$

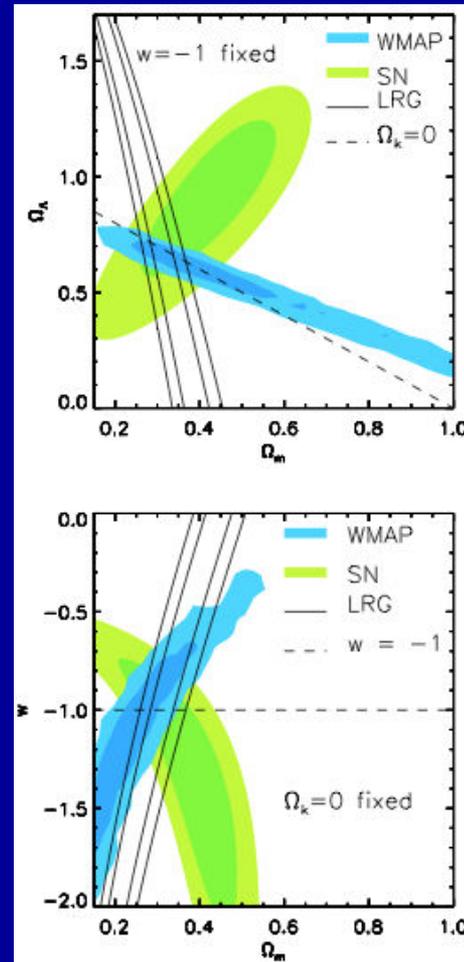


$$\Omega_m h^2 (n_s/0.96)^{1.2} = 0.141 \pm 0.011$$

$$D_V(z=0.35) = 1380 \pm 67 \text{ Mpc}$$

Combined Constraints: Geometry

- WMAP+LRG Λ CDM:
 $\Omega_m = 0.289 \pm 0.019$,
 $H_0 = 69.4 \pm 1.6$
- WMAP+LRG+SN:
 $\Omega_{\text{tot}} = 1.011 \pm 0.009$,
 $w = -0.99 \pm 0.11$
- Constraints slightly better for Percival et al. 2009 BAO



Combined Constraints: Neutrinos in Λ CDM

- P(k) constraints tighter than P09 BAO-only
- Massive neutrinos suppress P(k)
 - WMAP: $\Sigma m_\nu < 1.3$ eV (95% confidence)
 - WMAP+LRG: $\Sigma m_\nu < 0.62$ eV
 - WMAP+ BAO : $\Sigma m_\nu < 0.73$ eV
- Effective number of relativistic species N_{rel} alters turnover scale
 - WMAP: $N_{\text{rel}} = 3.046$ preferred to $N_{\text{rel}} = 0$ with $> 99.5\%$ confidence
 - WMAP+LRG: $N_{\text{rel}} = 4.8 \pm 1.8$
 - WMAP+BAO: $N_{\text{rel}} = 6.0 \pm 2.5$

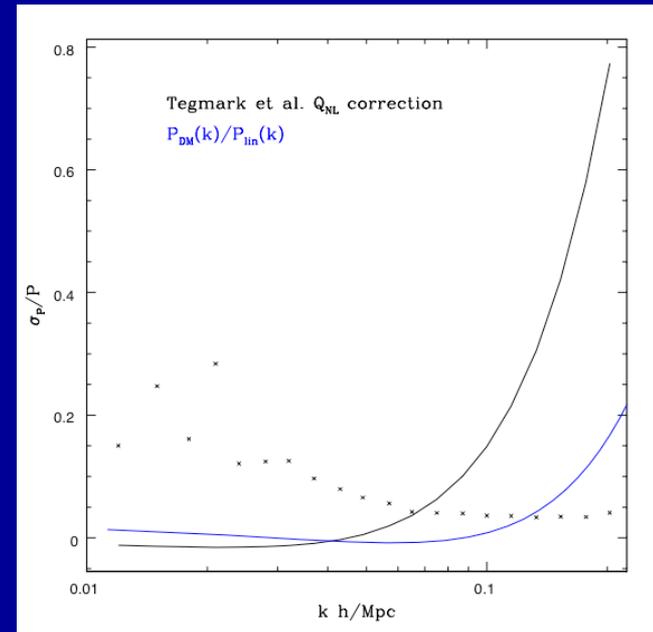
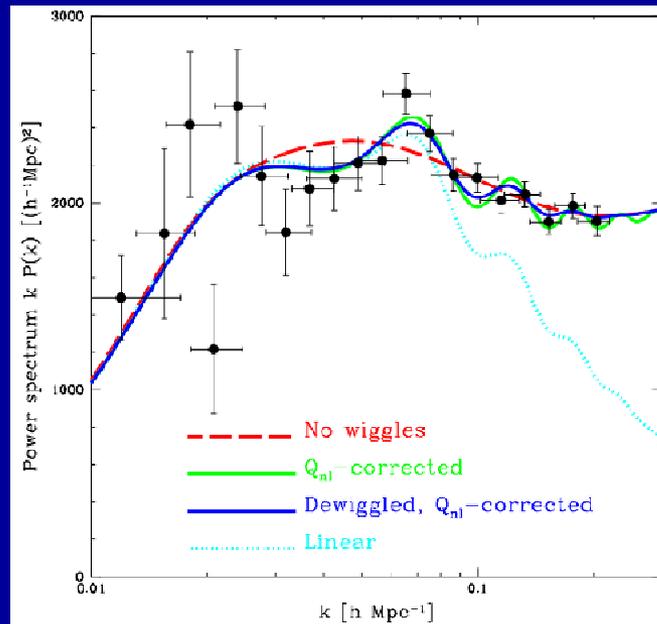
Summary & Prospects

- DR7 improvement: We use **reconstructed halo density field** in cosmological analysis
- Result: 8x more modes, improved neutrino constraints compared with BAO only analysis
- Likelihood code available here:
<http://lambda.gsfc.nasa.gov/toolbox/lrgdr/>
- Shape information comes “for free” in a BAO survey, e.g., BOSS
- Future -- extend halo model modeling to redshift space distortions to constrain growth of structure (e.g., Song and Percival 2008)

Why Study LRG bias?

- Statistical power compromised by Q_{NL} at $k < 0.09$!
[Dunkley et al 2008, Verde and Peiris 2008]

$$P_g(k) = P_{\text{dewiggled}}(k) b^2 \frac{1 + Q_{nl} k^2}{1 + 1.4k}$$



Tegmark et al 2006

