

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

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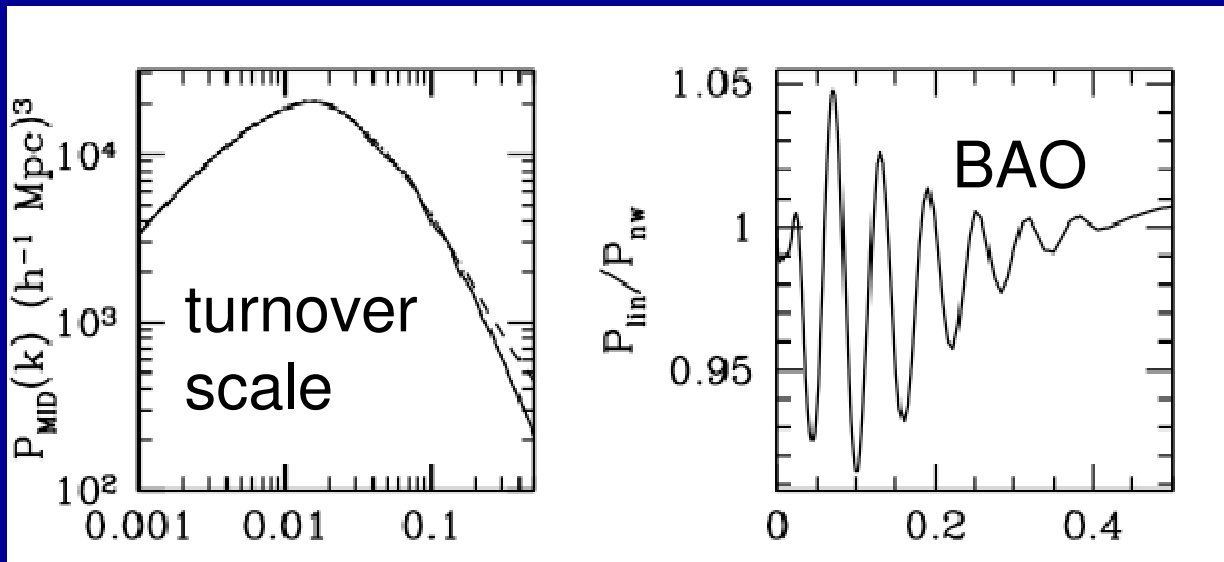
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D. Spergel, R. Skibba, SDSS TEAM

# 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  $\text{Mpc}^{-1}$  through  $\Omega_c h^2$  (6%) and  $\Omega_b h^2$  (3%), independent of  $\theta_{\text{CMB}}$



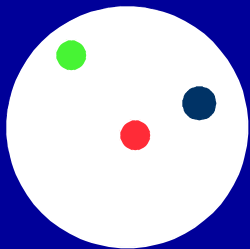
\* ignoring the effect of massive neutrinos, fixing  $N_{\text{rel}} = 3.046$

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

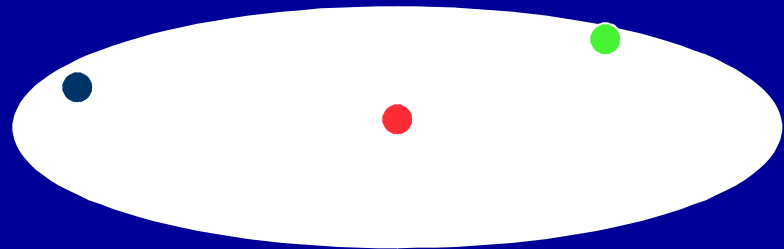
# Challenges

- density field  $\delta$  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

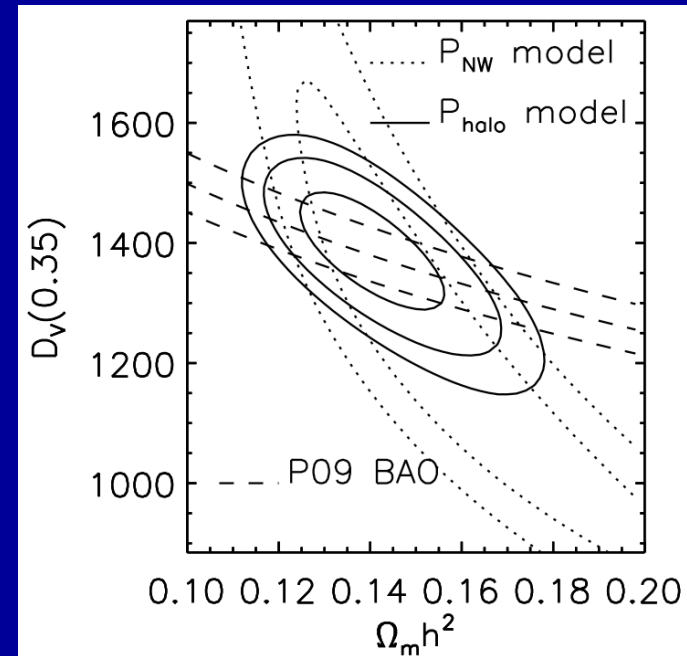
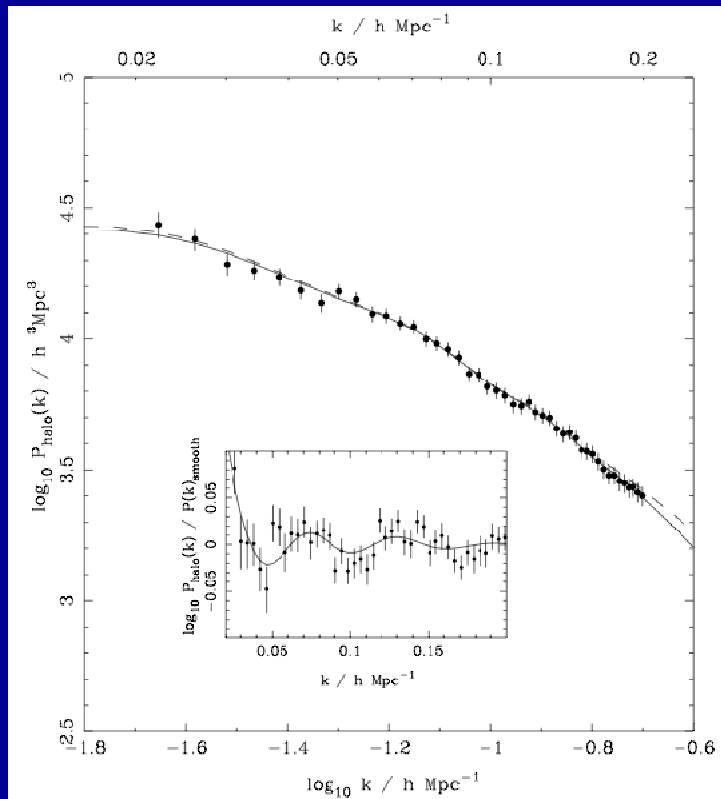
# WHAT'S NEW

- $n$  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 ( $r_s/D_V$ )

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

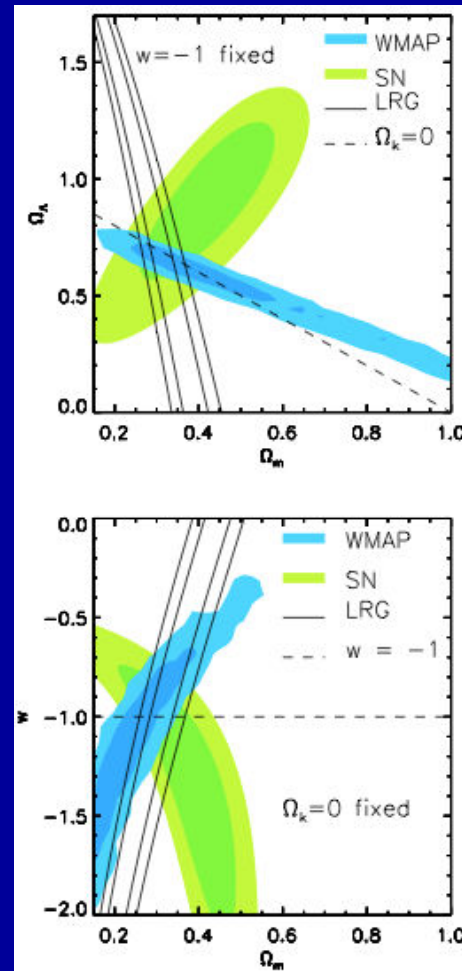


$$\Omega_m h^2 (n_s/0.96)^{1.2} = 0.141 \pm 0.011$$

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

# Combined Constraints: Geometry

- WMAP+LRG  $\Lambda$ 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 $\Lambda$ 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  $N_{\text{rel}}$  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:  $N_{\text{rel}} = 6.0 \pm 2.5$

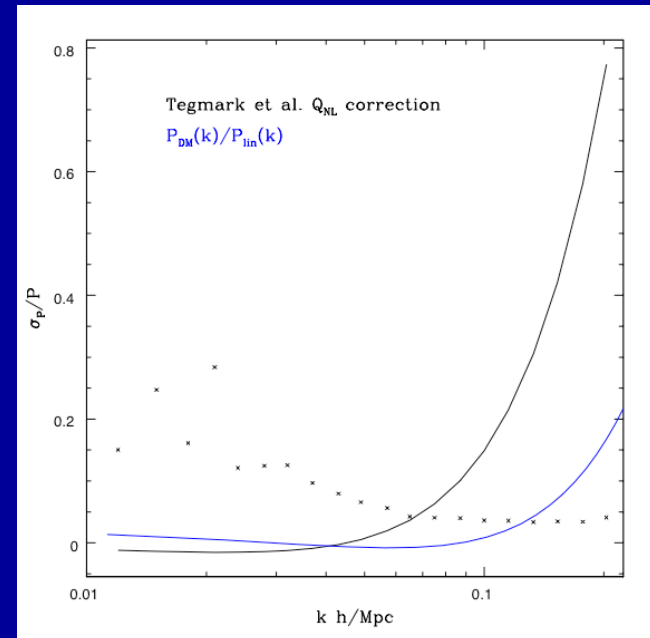
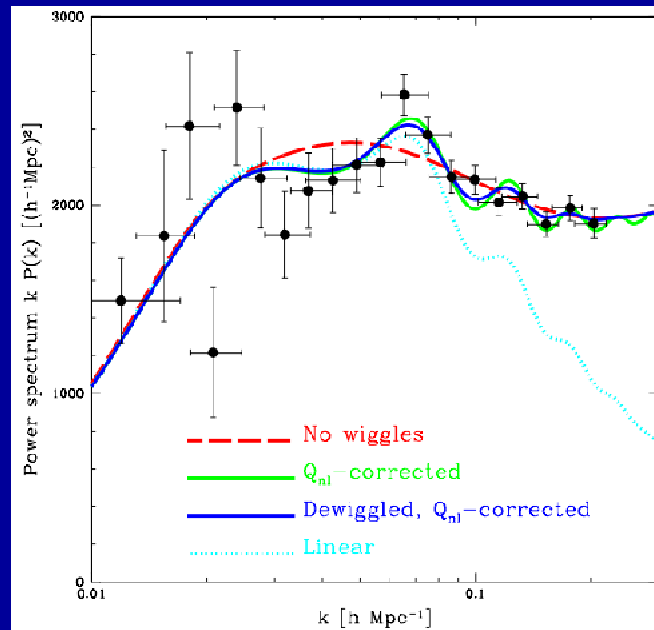
# Summary & Prospects

- 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

