Testing cosmological models with WiggleZ

Image credit: Sam Moorfield, Swinburne University

Chris Blake, Swinburne
Testing cosmological models with WiggleZ

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The WiggleZ Dark Energy Survey

- 1000 sq deg, $0.2 < z < 1.0$
- 200,000 redshifts
- blue star-forming galaxies
- 2006-2010
- 50% of data analyzed here
The dark energy puzzle

What is “dark energy”?

1) new, missing matter-energy component
2) failure of the laws of gravity
3) failure of the laws of quantum theory
4) systematic errors in our observations?
The dark energy puzzle

Image credit: Lawrence Berkeley National Laboratory
The dark energy puzzle

We need to make simultaneous measurements of the cosmic expansion and growth histories

Image credit: Lawrence Berkeley National Laboratory
Clustering pattern
Amplitude of long-wavelength structure modes

Amplitude of short-wavelength structure modes

We can model this function from theory

Clustering pattern

Power spectrum \( P(k) \)

Fourier wavescale \( k \)
Modes beyond the turn-over?

Fractional error better than 5% in 0.01 h/Mpc bins

Linear bias & z-space distortion model produces good fit to k>0.3 h/Mpc

Combined WiggleZ regions Oct−09 0.3<z<0.9
Model is $\Omega_m=0.3$, $f_b=0.17$
Expansion history: baryon oscillations

SDSS
Percival et al. (2007)
Expansion history: baryon oscillations

Tentative 2-sigma detection
(50% of the data still to be added in)

Combined WiggleZ regions Oct−09 0.3<z<0.9
Model is $\Omega_m=0.3$ $f_b=0.17$
Expansion history: baryon oscillations

Model is:
\[ \Omega_m = 0.3, \quad f_b = 0.17, \quad h = 0.72, \quad \sigma_8 = 0.8, \quad n = 0.96, \quad z_{\text{eff}} = 0.6, \quad \beta = 0.7, \quad \sigma_v = 300 \text{ km/s}, \quad b = 1.1 \]

Tentative 2-sigma detection (50% of the data still to be added in)

z = 0.35: Eisenstein et al. (2005)

z = 0.6: WiggleZ (Oct 2009)
Growth history: redshift-space distortions

- Infalling galaxies
- Virialized motions
- Coherent flows

Observer

Line-of-sight offset / $h^{-1}$ Mpc

Projected offset / $h^{-1}$ Mpc
Growth history: redshift-space distortions
Growth history: redshift-space distortions

![Graph showing growth rate $f\sigma_8(z)$ as a function of redshift $z$. Data points from 2dFGRS, SDSS-LRG, and WiggleZ are plotted.](image-url)
Growth history: redshift-space distortions

![Graph showing growth rate $f\sigma_8(z)$ vs. redshift $z$. Three datasets and models are compared: Flat ΛCDM, Flat DGP, and SUGRA. The graph includes data points for 2dFGRS, SDSS-LRG, WiggleZ, and VVDS.](image_url)
Cosmic topology

WiggleZ 15-hr region :

Credit : Berian James

What is the genus?

```
genus 0

[A topologist is someone who can't tell their doughnut apart from their coffee mug]
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Cosmic topology

Credit: Berian James

Dashed line is Gaussian random field

Smooth on non-linear scale (10 Mpc)

Smooth on linear scale (30 Mpc)
Conclusions

- WiggleZ **power spectrum** is nicely fit by theory with matter/baryon densities consistent with CMB.

- **Baryon oscillations** currently detected at ~2-sigma significance [~3-sigma at survey end].

- WiggleZ gives most accurate **growth measurement**, extending previous work to higher redshift.

- **General relativity / cosmological constant** models remain a good fit.
Thank you!