Colour and Luminosity Dependence of Galaxy Clustering

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and the GAMA collaboration

Motivation

- Flux-limited surveys are dominated by ~L* galaxies - fainter surveys simply detect them to higher redshift
- There have been dedicated surveys for luminous galaxies (SDSS LRGs, 2SLAQ, AUS)
- Properties of sub-L* galaxies are relatively poorly constrained
- One way of increasing sample sizes is to use photometric redshifts, either for target pre-selection or luminosity estimation

This work

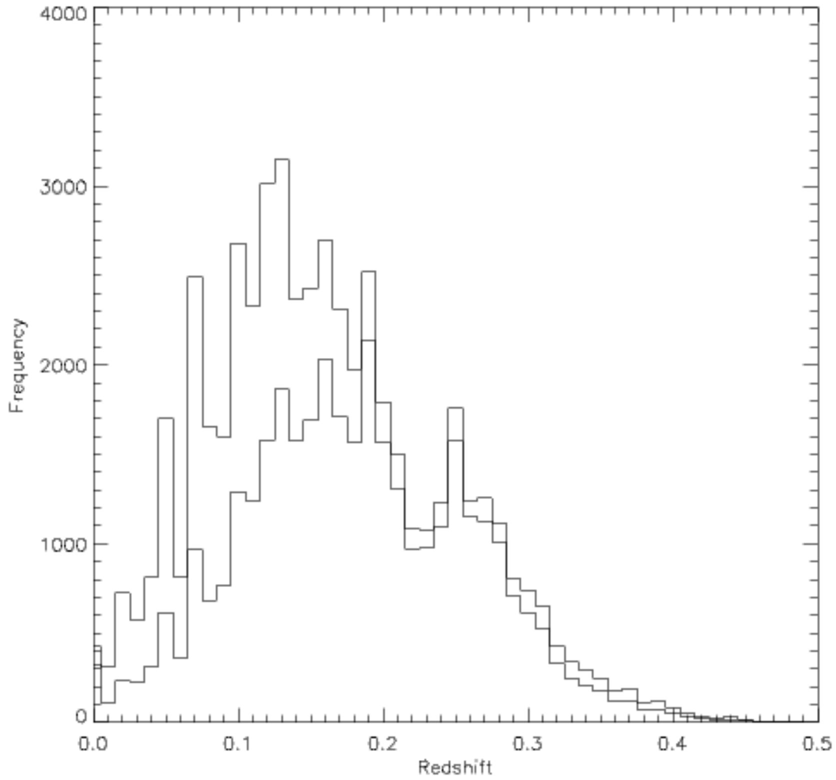
- We measure the angular correlation function $w(\theta)$ of almost 3 million SDSS galaxies with $r < 19$ subdivided by luminosity and colour as determined from photometric redshifts
- $w(\theta)$ measured for galaxies with $M_r > -17$ (h=1) for first time
- Photometric dN/dz distribution for each subsample used in Limber inversion to obtain correlation length

Photometric Redshifts

- Estimated using artificial neural network algorithm ANN*z* (Collister & Lahav 2004)
- Network architecture 7:11:11:1 with inputs SDSS *ugriz* model magnitudes, R_{50}, R_{90}
- Committee of five networks
- ~60,000 GAMA redshifts to $r < 19$:
    - 3/8 for training
    - 1/8 for verification
    - 1/2 for testing (numbers shown on plots)

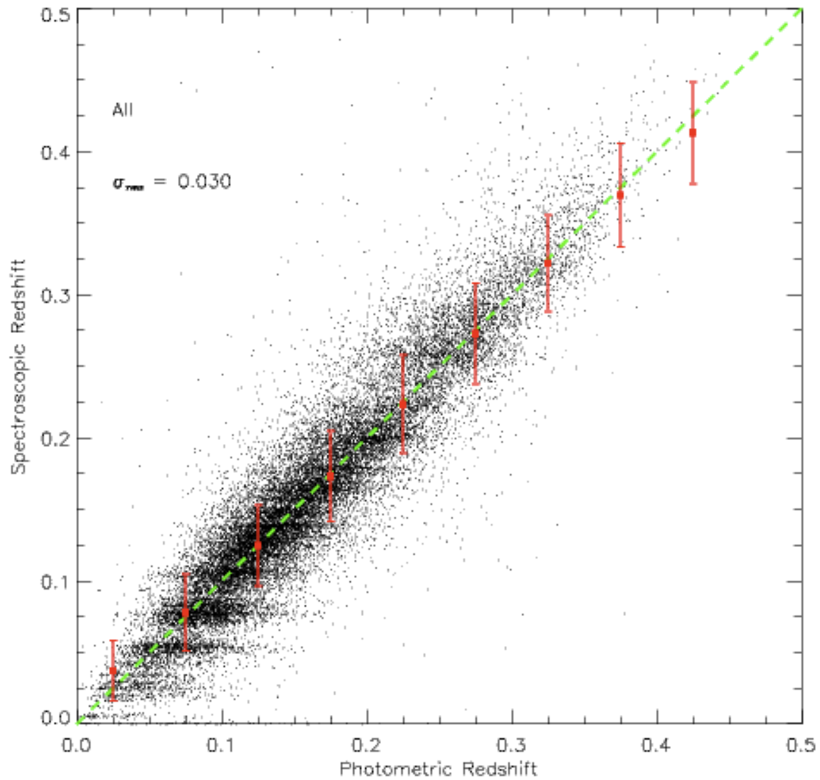
GAMA Redshift Distribution

- Upper curve: all available (GAMA, SDSS, 2dfGRS, 6dFRS, MGC)
- Lower curve: new GAMA redshifts



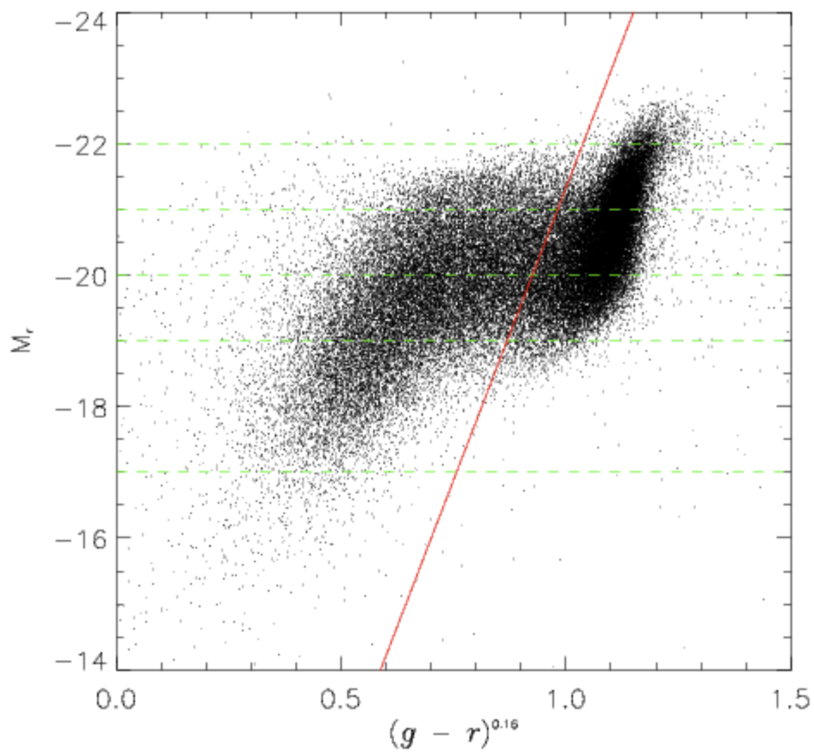
Photometric Redshifts

- σ = 0.030
- Essentially unbiased to z = 0.4
- Competitive with SDSS DR6 photo-z estimates



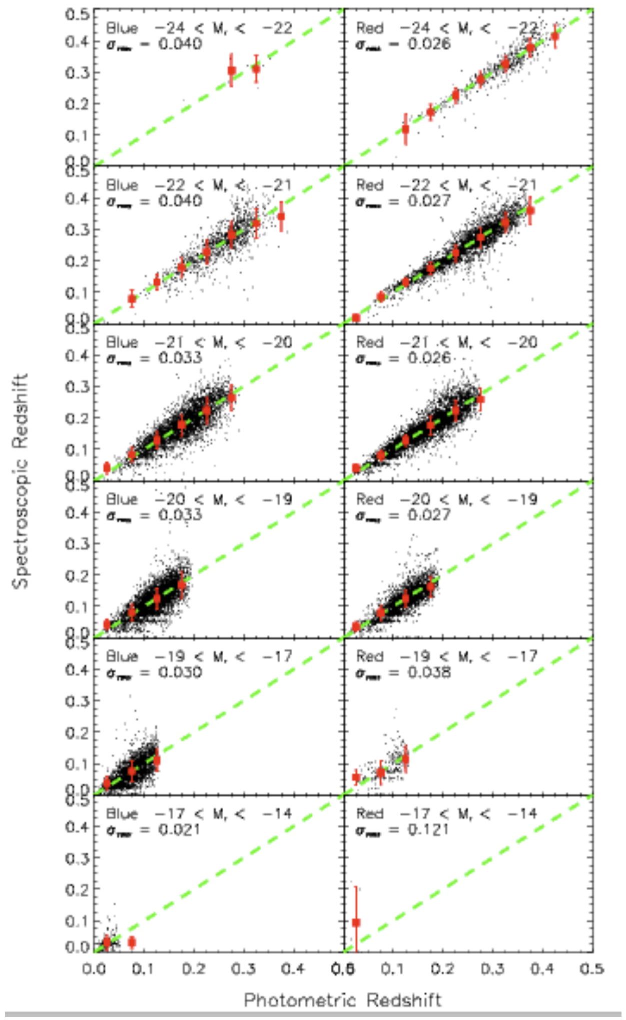
Subsamples

- Use ANNz photo-z to estimate luminosities and colours for each of ~3 million SDSS galaxies with r < 19
- Divide sample into 6 luminosity bins -24 < r < -14 and two colour bins a la Zehavi et al 2005



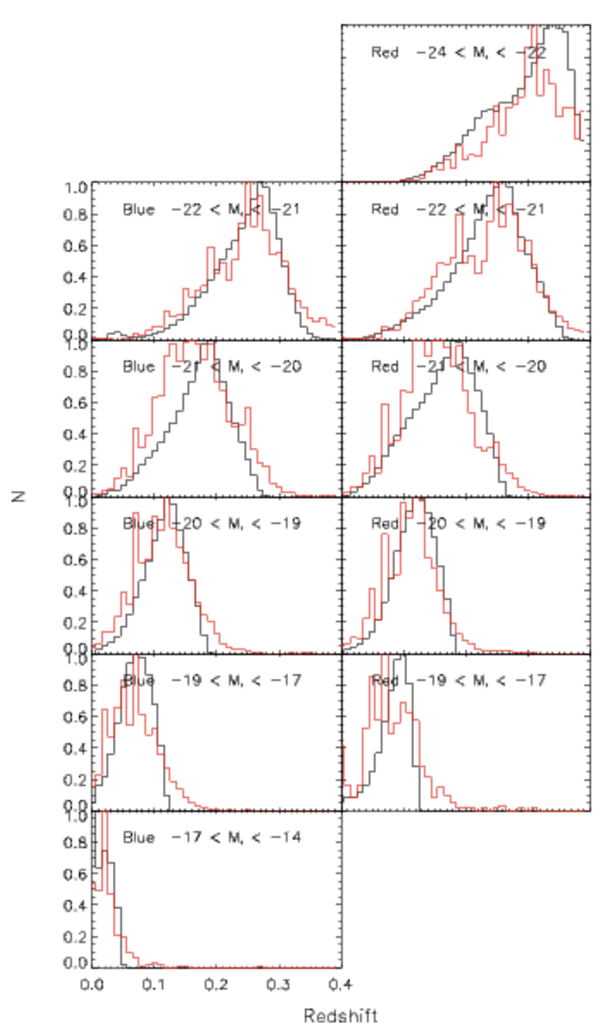
Subsample Photo-zs

- Network trained once on entire sample
- Compare spec and photo-z for “unseen” galaxies
- No significant biases in subsamples
- Insufficient blue galaxies in most luminous bin, red galaxies in faintest bin



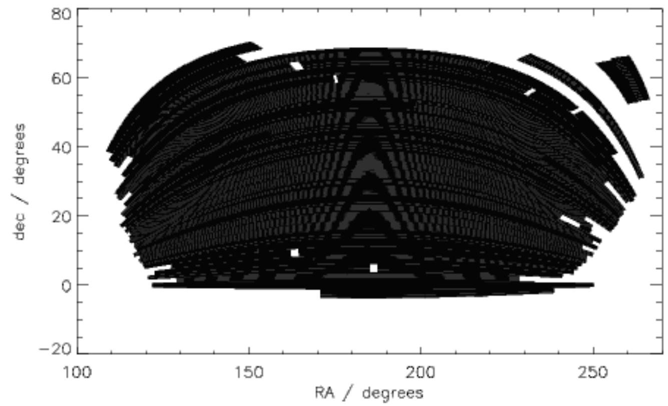
dN/dz

- Used in Limber inversion to find correlation length r_0, where $\xi(r) = (r/r_0)^{-\gamma}$
- Using spectro-z (shown in red) increases inferred r_0 by about 1σ relative to using photo-z due to high-z tail not present in photo-z

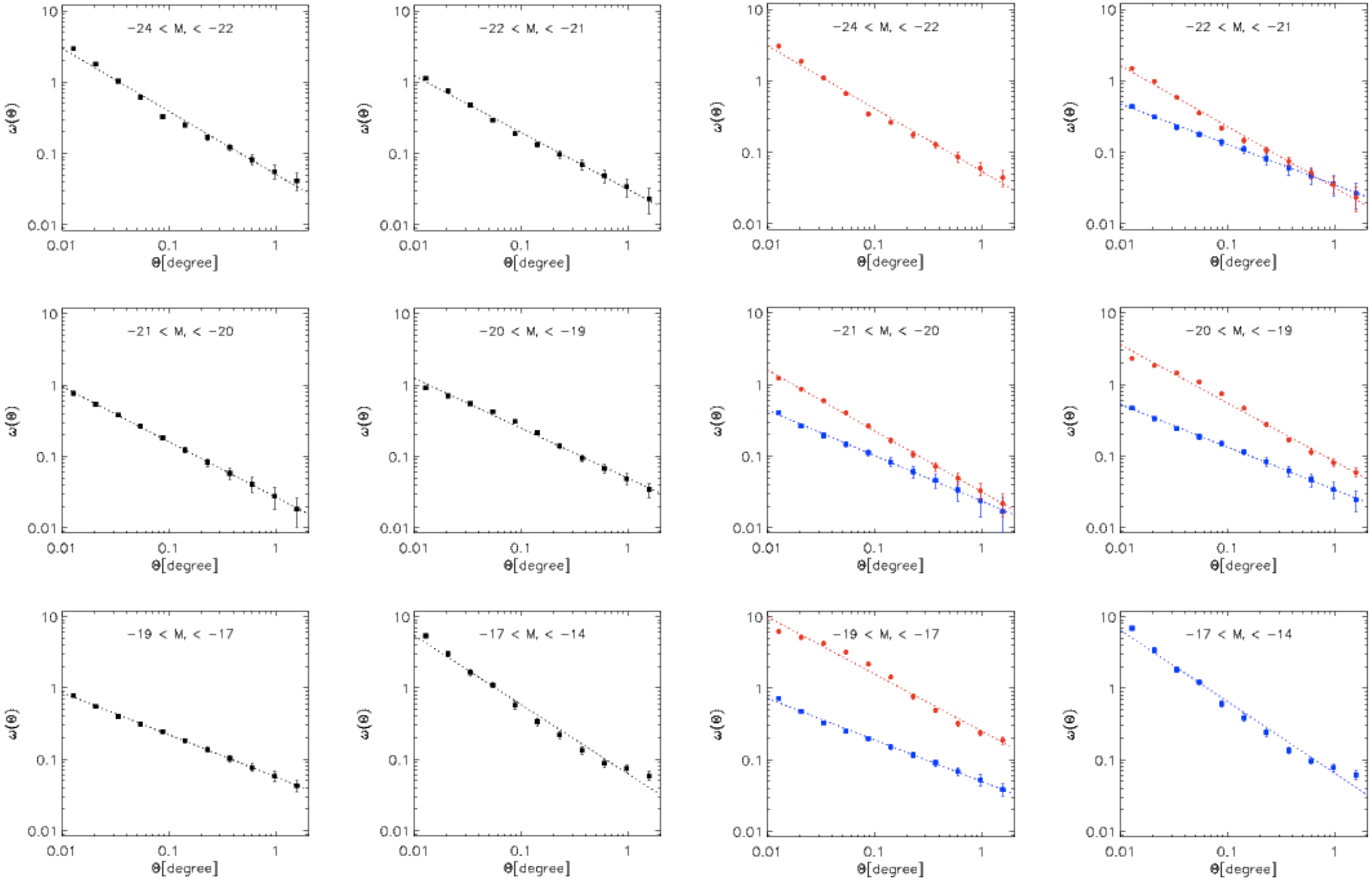


w(θ) Calculation

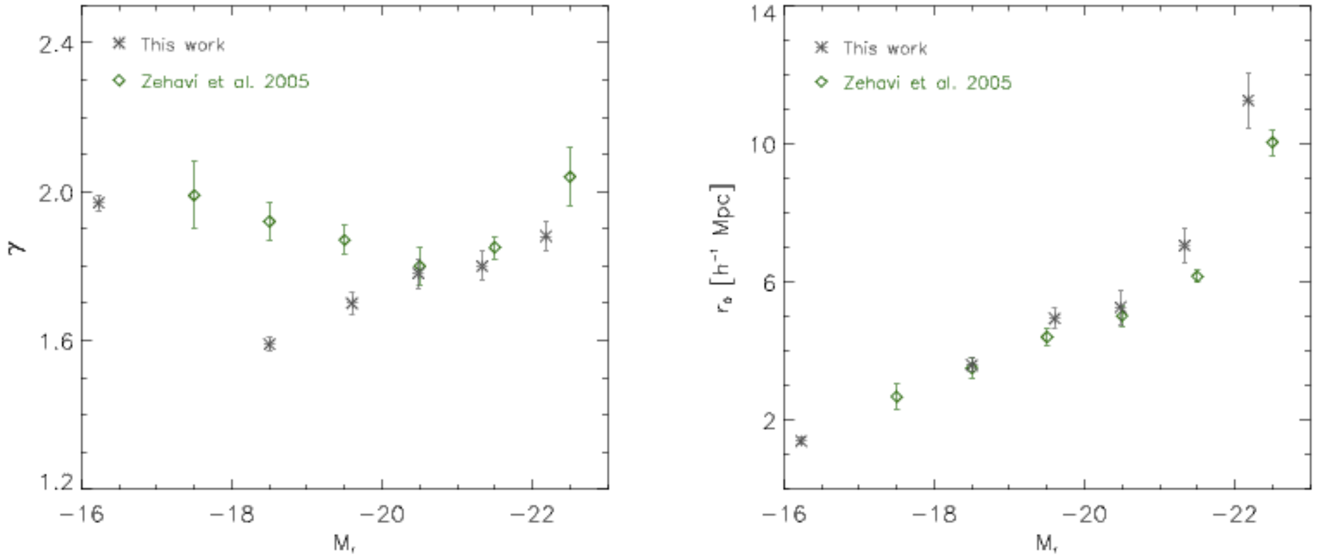
- Select r < 19 galaxies from SDSS DR6 north galactic cap region (8417 square degrees)
- Exclude regions near Tycho-2 stars (B < 13), RC3 galaxies, colour outliers
- Use Landay-Szalay estimator with 10x as many random points as galaxies and using SDSSPIX pixelisation scheme for efficiency
- Errors from 9 jack-knife samples



w(θ) Results

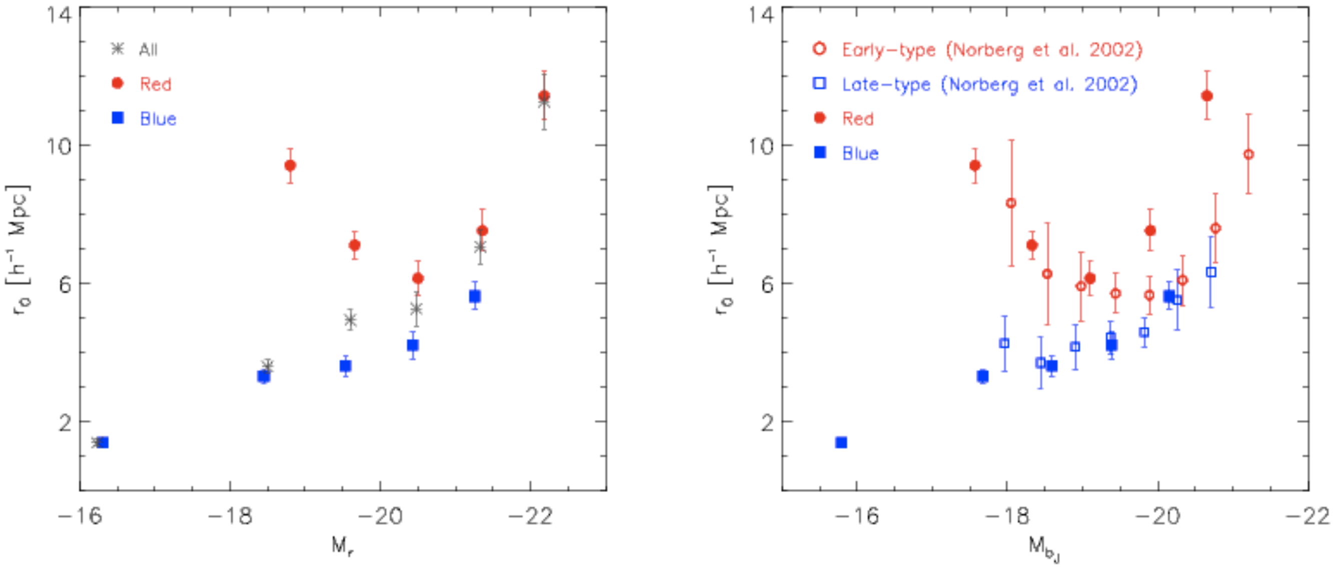

−24 < M, < −22
−22 < M, < −21
−24 < M, < −22
−22 < M, < −21
−21 < M, < −20
−20 < M, < −19
−21 < M, < −20
−20 < M, < −19
−19 < M, < −17
−17 < M, < −14
−19 < M, < −17
−17 < M, < −14
ω(θ)
θ[degree]
0.01
0.1
1
10

Trends with Luminosity



- γ steepens with luminosity except for [-17, -14]
- r_0 monotonically decreasing to fainter galaxies

Colour Dependence



- Red galaxies: r_0 has minimum around L*
- Blue galaxies: r_0 increases monotonically with luminosity

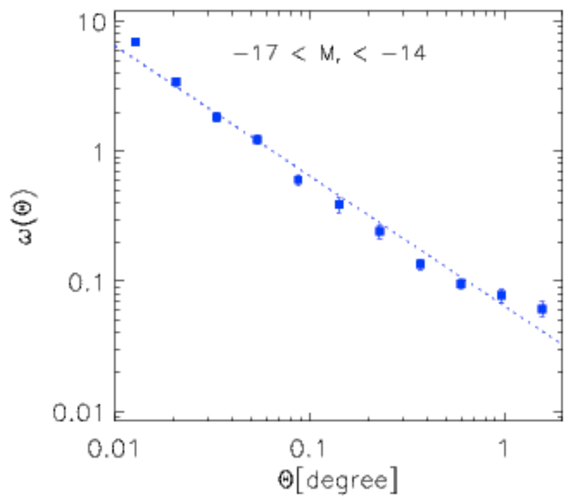
Discussion

- Estimates of correlation length r_0 consistent with previous estimates (Norberg et al. 2002, Zehavi et al 2005)
  - r_0 for red galaxies increases at both luminosity extremes
    - Luminous red galaxies found in cluster cores; faint red galaxies are satellites
  - r_0 for blue galaxies increases monotonically with luminosity

Discussion contd.

- Power-law slope γ tends to steepen with increasing luminosity - almost entirely due to blue galaxies
- However, faintest [-17, -14] blue galaxies show steep slope, $\gamma \approx 2$
- These faintest blue galaxies may be satellites in small (< 1 Mpc) dark matter halos where low density allows star formation to continue
- Evidence for star-formation in low-mass systems in groups

To Dos



- Power-law fits using full covariance matrix, using more jack-knife samples
- Fit over consistent range of physical scales accounting for mean redshift of each sample - is change in slope at 0.7° (1 Mpc/h) for faintest blue galaxies real?
- Use smoothed spectroscopic dN/dz in Limber inversion

Future Prospects

- Completed GAMA survey will allow photo-z calibration to r = 19.8
- To go fainter than $M_r \approx -14$ will require deep ($r \approx 22$) spectroscopic survey using VST/VISTA imaging data
- Combined optical/near-IR photometry will allow reliable photo-z pre-selection for such a survey thus avoiding "excessive" L* galaxies