

Large Scale Structure at the End of the Dark Ages

Elizabeth Stanway
(for Laura Douglas)



Also thanks to: Malcolm Bremer, Matt Lehnert, Aprajita Verma

A Century of Cosmology, Venice, 30th August 2007

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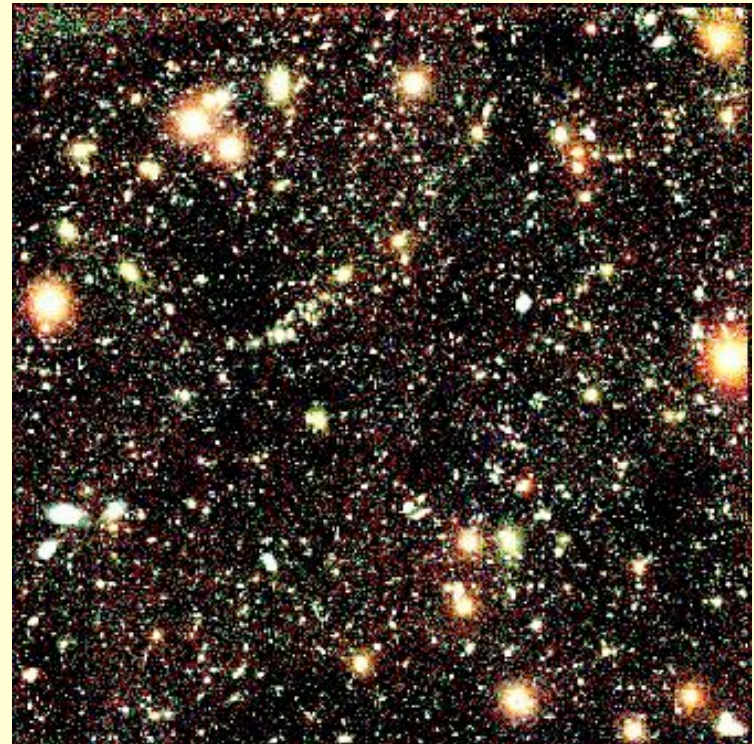


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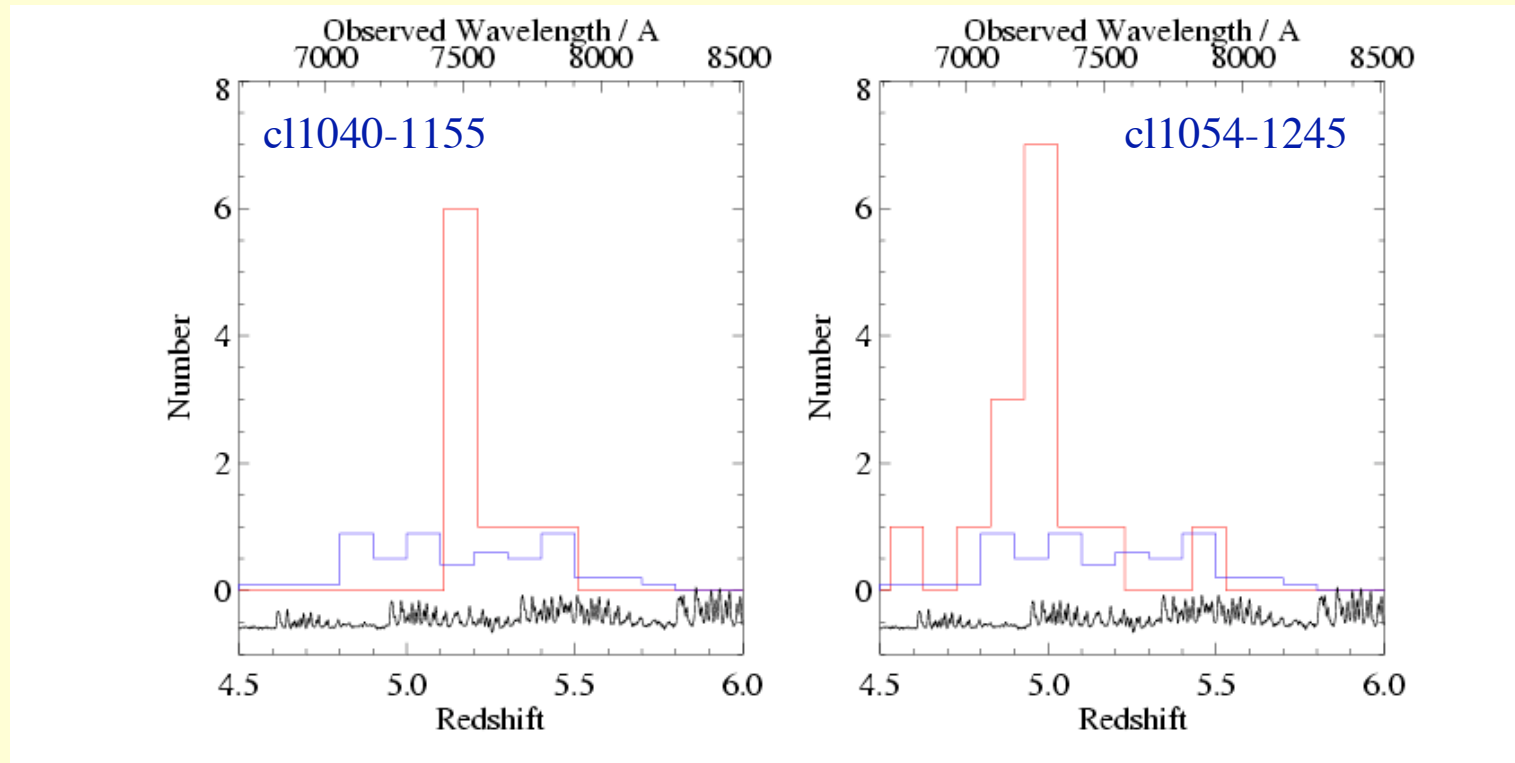
The ESO Remote Galaxy Survey (ERGS)

- Targets the 10 EDisCS Survey cluster fields (VRIJK)
- Adds Z band imaging and 100hrs of spectroscopy
- 20 VLT/FORS2 Slitmasks
- Targets R-drops with $R-I > 1.3$, $I_{AB} < 26.3$
- $R \sim 660$, $\lambda \sim 6500-10000 \text{ \AA}$
- ESO/VLT Large Programme
- ~ 70 Confirmed Redshifts at $4.4 < z < 6.4$ including lines and breaks



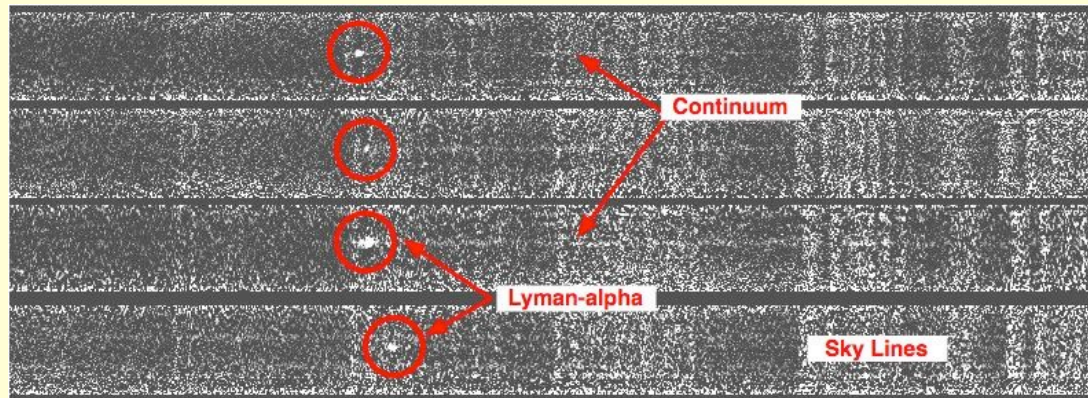
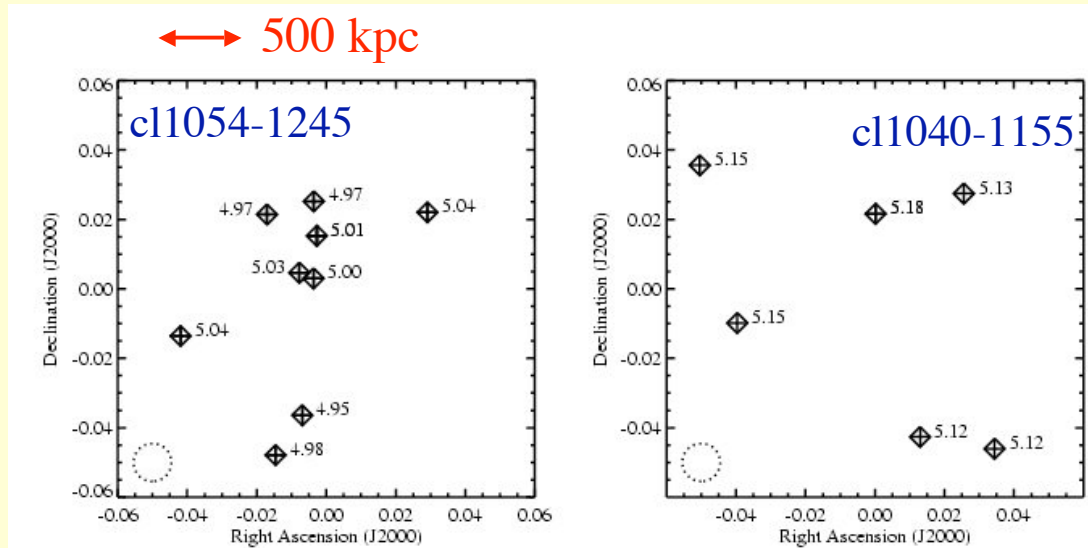
VRI image of CL1037-1243

Redshift Spikes in the ERGS Sample



- Spikes in the redshift distribution of spectroscopically-confirmed galaxies at $z=5.00$ and $z=5.15$ in different fields
- These are $>5\sigma$ overdensities BUT are broad (i.e. $\Delta z=0.1$ and $\Delta z=0.15$) and may indicate filamentary structure rather than spherical halos.

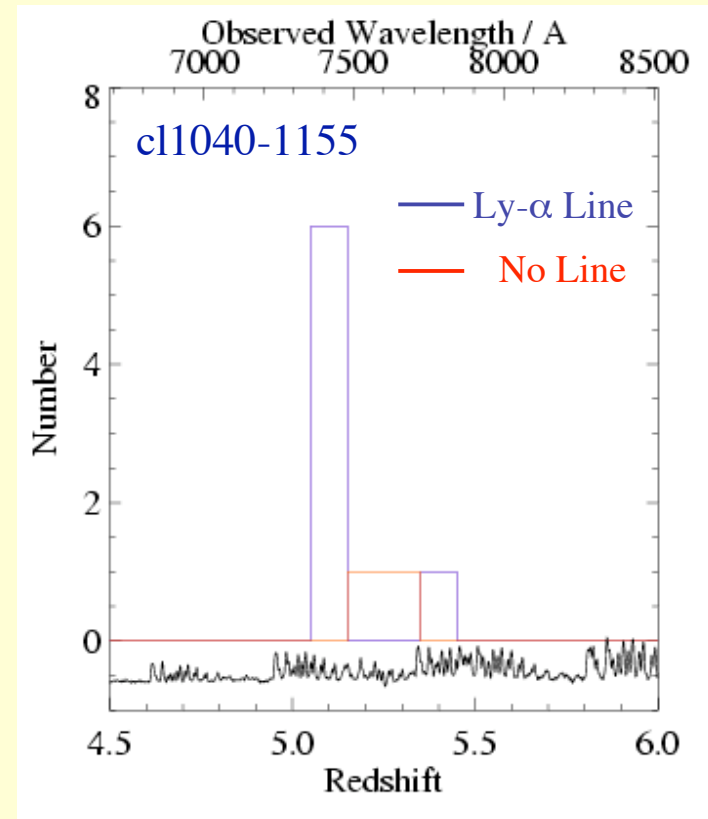
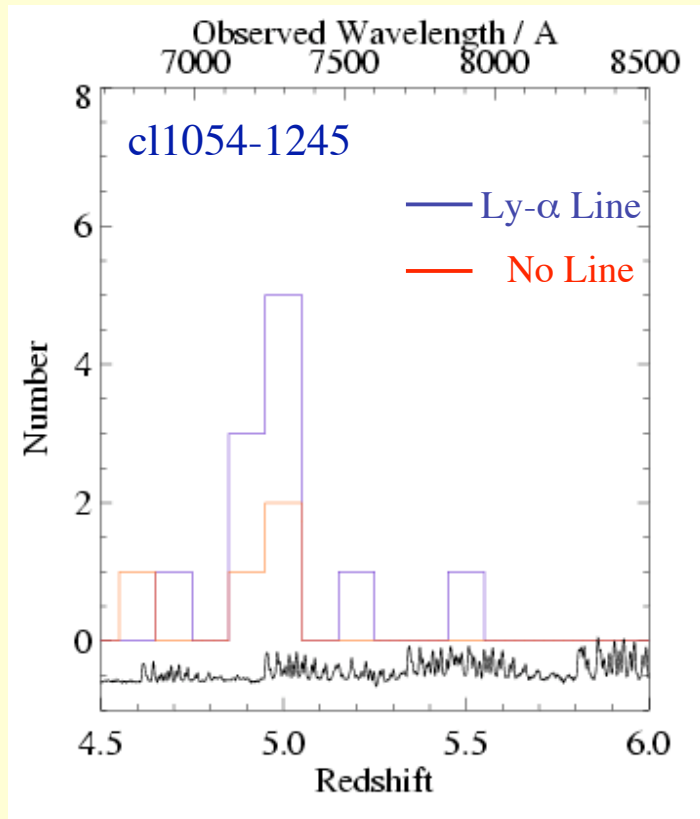
Overdensities at $z=5.00$ and $z=5.15$



Examples of Lyman Break galaxy spectra in c11054-1245

- These structures may extend beyond the limits of the imaging fields
- One of the fields shows evidence for spatial as well as redshift clustering
- Redshift precision is better than 0.002
- The redshift spikes are not in skyline-free wavelength regions

Lyman- α Emitters and Lyman Break Galaxies



Lyman- α Emitters appear to be more sensitive tracers of large scale structure than galaxies without line emission, i.e. line emitters are more highly biased than older galaxies at comparable magnitudes

The Progenitors of Massive Ellipticals

- Verma et al (2007) found that $z \sim 5$ galaxies selected by dropout surveys are largely young (< 100 Myr)
 - This implies stochastic star-bursting, with many dormant galaxies for each Lyman Break galaxy at each redshift
 - The ERGS structures are too large to be triggered by interactions between UV-bright galaxies but highly unlikely to be chance superposition
- ⇒ The UV-selected galaxies mark out stochastic bursts within a much larger structure

This is consistent with fossil population studies (e.g. Panter et al 2007, Thomas et al 2005) which suggest that $z \sim 5$ is the formation epoch of today's giant ellipticals

Exploring Large Scale Structure at Early Times

Open Issues:

- What form is the UV-dark material in? (Gas? Dust? DM?)
- Where are all the baryons? (Only a few percent accounted for)
- Why are the redshift spikes so broad?

Future Approaches:

- Infrared - SED fitting, Spectroscopy, Stellar Populations
- Submillimetre/Centimetre - CO, [CII], HI, continuum
- More large spectroscopic surveys with multiple fields

Conclusions

- The ESO Remote Galaxy Survey (ERGS) is the largest uniformly selected $z \sim 5$ Lyman Break galaxy sample with high spectroscopic completeness
- By studying 10 widely separated fields, ERGS directly measures the cosmic variance of this population
- We have identified two ‘spikes’ in redshift space, which represent $>5\sigma$ overdensities of galaxies above the survey norm.
- These likely mark out larger UV-dark structures
- These systems have the properties expected of the progenitors of present-day giant ellipticals

See Douglas (PhD thesis) and forthcoming papers for more details