The DEEP2 Galaxy Redshift Survey: the Relationship Between Galaxy Properties and Environment at z~1

Cooper et al. (2006)

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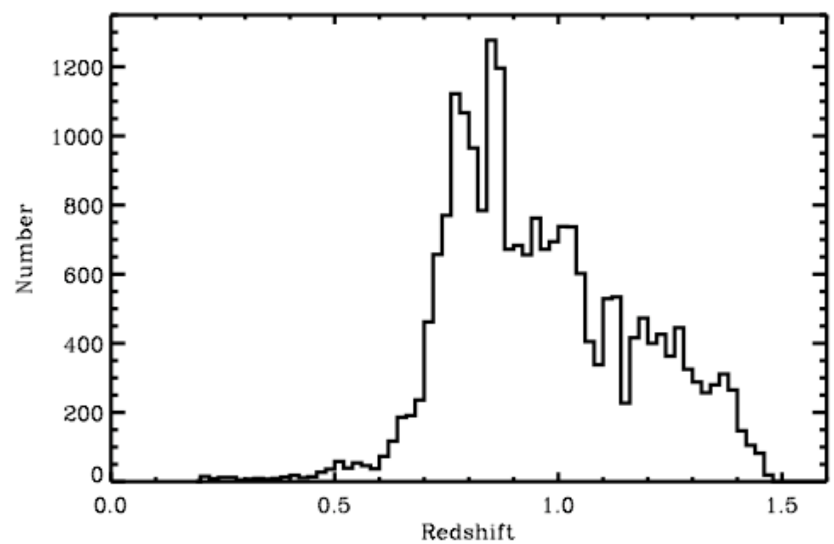
Sample

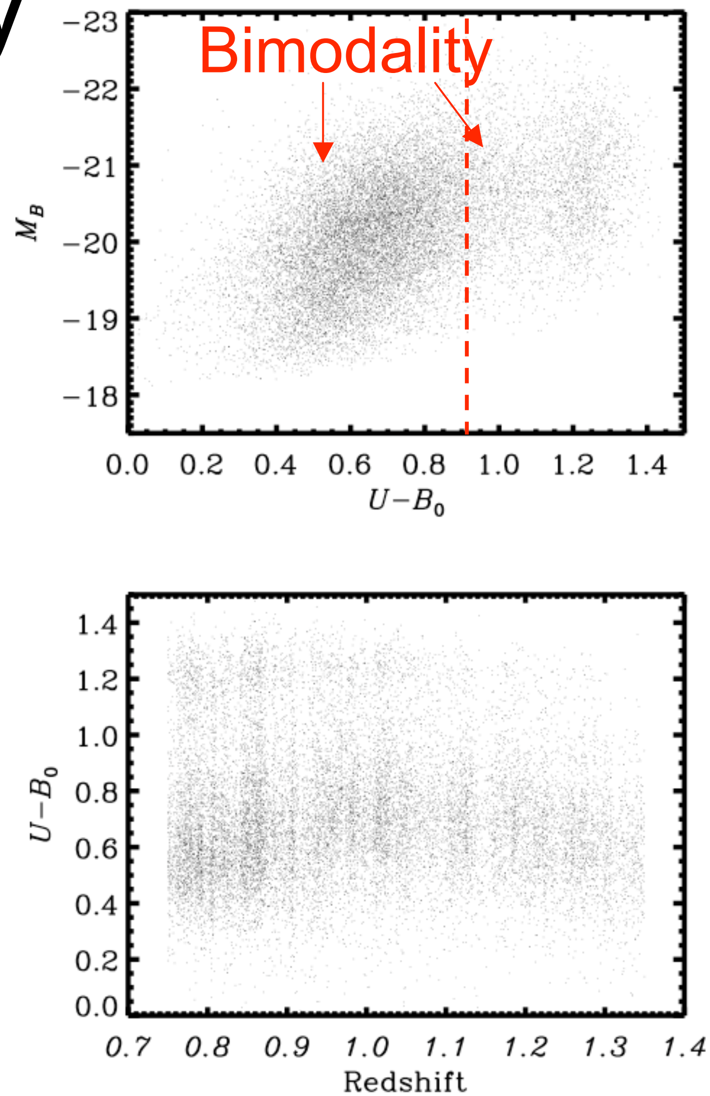
- DEEP2 GRS
- Deep B,R,I imaging using CFHT
- $R_{AB} \leq 24.1$
- DEIMOS spectrograph on 10m Keck-II (high res., $6300 \leq \lambda \leq 9100$ Å)
- Covers 3 deg^2 of sky over 4 fields
- ≥ 97% completeness of $z > 0.7$

Sample	Redshift range	Edge distance	$W_{[O\,II]}$	# of galaxies
Sample A	$0 < z < 2$	–	–	23 004
Sample B	$0.75 < z < 1.35$	–	–	18 977
Sample C	$0.75 < z < 1.35$	$>1\,h^{-1}$ Mpc	–	14 214
Sample D	$0.75 < z < 1.35$	$>1\,h^{-1}$ Mpc	$\sigma_{W_{[O\,II]}} < 10$ Å	11 250
Sample E	$0.75 < z < 1.05$	$>1\,h^{-1}$ Mpc	–	9567



Galaxy Property: Color & Luminosity

- K-corrections
- Color bimodality
- Little evolution other than selection effects

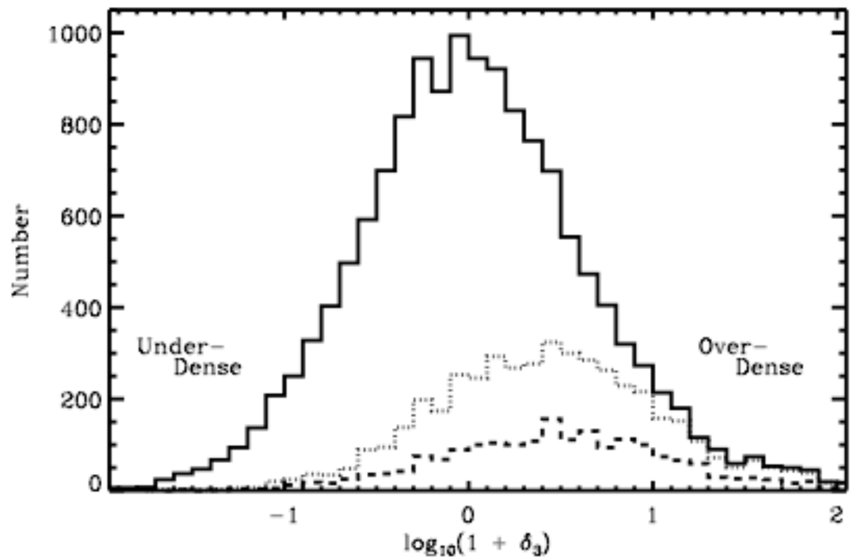


Galaxy Property: $W_{[OII]}$

- [OII] 3727 Å doublet
- Use only galaxies with small equivalent width errors (~45% of galaxies)
- SF indicator

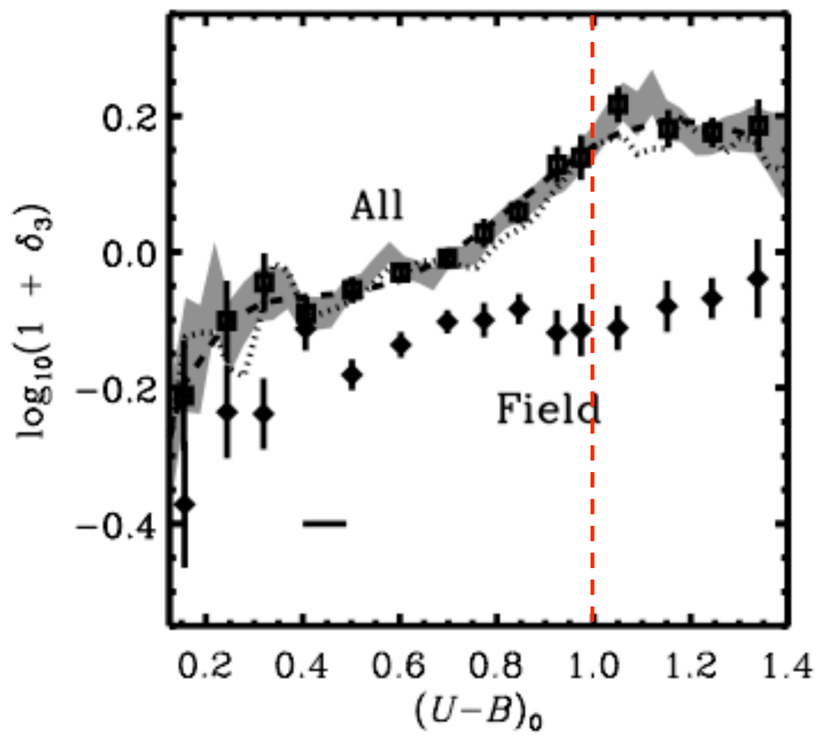
Galaxy Property: Local Density

- 3rd-nearest-neighbor surface density $\Sigma_3 = 3/(\pi D^2_{p,3})$
- Exclude foreground and background galaxies by limiting ±1000 km/s along LOS
- Minimizes role or redshift-space distortions & edge effects
- $(1+\delta_3)$ = overdensity relative to mean density



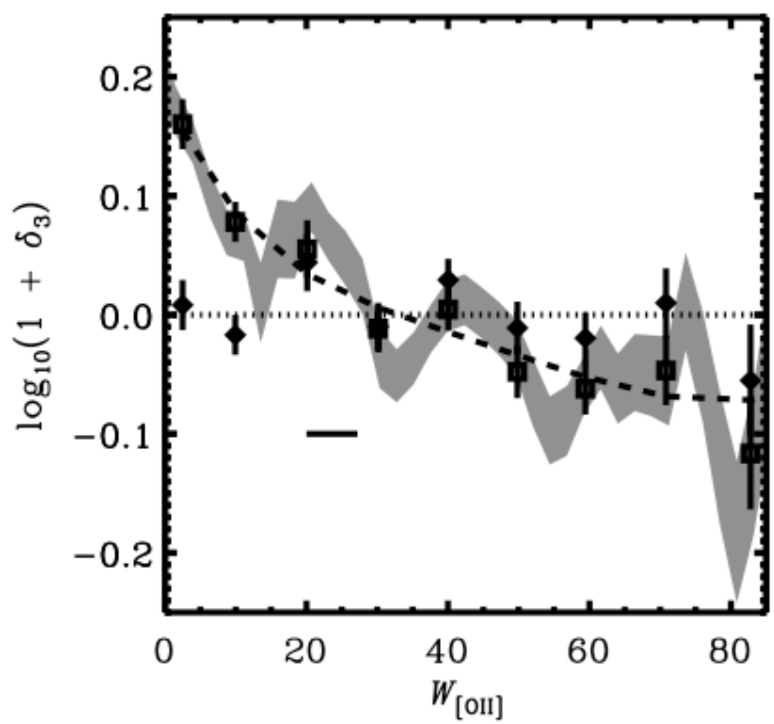
Results: Color

- Blue galaxies - less dense environments
- Transitions at $(U\text{-}B)_0 \sim 1$
- Red galaxies (@ z~1) density = 1.5 x blue galaxies density
- Color dependent density at z~1 similar to z~0.1



Results: $W_{[OII]}$

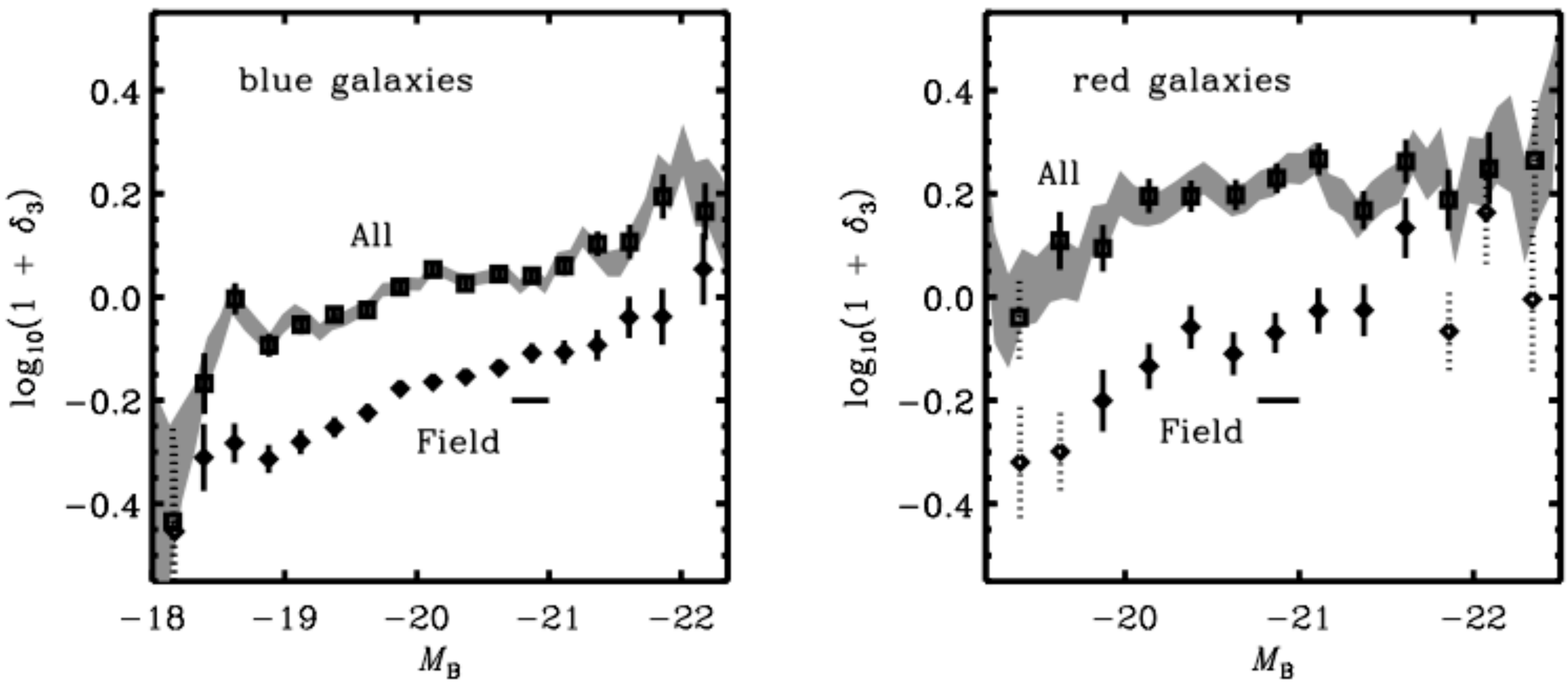
- Galaxies with smaller $W_{[OII]}$ in higher density regions
- Can be attributed to correlation with color
- When removing color dependence, no density-$W_{[OII]}$ correlation



Why would they not agree?

- $W_{[OII]}$ traces instantaneous SF
  - can be influenced simply by minor mergers
  - Not necessarily tied to local density and big interactions
  - can be influenced by AGN activity
- $(U\text{-}B)_0$ traces SF on longer time-scales
  - Strongly correlated with large-scale environment

Results: Luminosity



Which property works best?

Galaxy property	$(\sigma_X^2 - \sigma^2)$	$(U-B)_0$	$W_{[O\,II]}$	M_B
$(U-B)_0$	−0.0076	–	−0.0075	−0.0160
$W_{[O\,II]}$	−0.0019	−0.0075	–	−0.0147
M_B	−0.0031	−0.0160	−0.0147	–

- $(U\text{-}B)_0$ is best single predictor of environment
- Combination of color and luminosity are most strongly correlated pair with environment

What’s causing this?

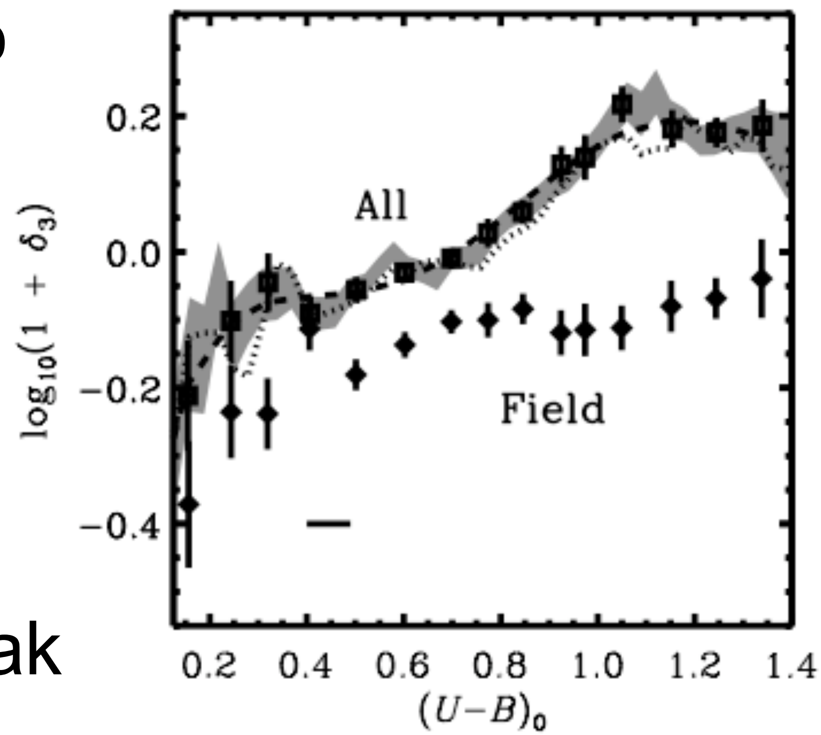
- Downsizing of quenching with redshift
- Quenching - suppression of SF in blue galaxies
- Downsizing - typical mass at which a blue SF galaxy is quenched has decreased with time
- Supported by dependence of mean environment on luminosity for blue galaxies

More on Quenching

- Causes?
  - Stripping of gas due to hydrodynamical and tidal effects
  - AGN
- Bright blue galaxies in overdense environments at z~1 evolve into red galaxies at z~0
- Entry into red sequence via quenching is less massive at z~0 than z~1

Field, Group, or Cluster?

- Each galaxy assigned to a family
  - ~2 % in clusters
  - ~30% in groups
  - ~67% in field
- cluster mechanisms cannot explain it all
- Field dependence is weak -> Groups dominate



What causes quenching?

- As dark matter halos assemble, cold infalling gas remains at virial temp until ~2-3x10^{11} $M_{\odot}$ when cold gas is shut off and SF ends
- Galaxy mergers (preferentially occur in groups) strips cold gas and shuts off SF
- Secular evolution (between bulge and disk) can funnel gas to SMBH

Conclusions

- Blue galaxies (@ z~1) on average live in lower density environments (like z~0)
- More luminous (@ z~1) red galaxies live in denser environments (like z~0)
- More luminous blue galaxies (@ z~1) live in denser environments (not like z~0)
- Color and luminosity are best predictors of environment at z~1

Conclusions

- Cluster mechanisms cannot explain observed relationships between galaxy properties and environment
- Downsizing of quenching mass or luminosity consistent with data in both clusters and groups
- Quenching mechanism not quite understood