Evolution of galaxies from mass selected samples

ACS GTO team (Holden, vdWel, Ford, Illingworth et al)

Fires Survey: Labbe, Wuyts, Kriek, Rudnick, Forster Schreiber, van Dokkum, Moorwood, Rix, Rottgering, Trujillo, van der Werf, Illingworth, van Starkenburg, MF,

MUSYC near-IR survey: van Dokkum (PI), Gawiser (co-PI), Lira (co-PI), Urry, Maza, Mendez, Altmann, Blanc, Francke, Barrientos, Infante, Urry, Quadri, Toft, Marchesini, Brammer, Taylor, MF

Kriek
Our goal is: study galaxy evolution

- This requires a proper census of the universe!
2 case studies

• Structure of galaxies at $z=1$ as a function of environment
• Evolution of Galaxies at $z=2-3$
Evolution Morphology-density relation (Dressler et al 1997)

Low redshift  

Z=0.5
Extending to $z=0.8$

- $190 > \Sigma > 27 \text{ gal Mpc}^{-2}$

- $M_V < M_{V,*} + 1$

- $\Sigma > 190 \text{ gal Mpc}^{-2}$

- $M_V < M_{V,*} + 1$
$M_V < M_{V,*} + 1.0$

$\Sigma$ (gal Mpc$^{-2}$)
Early-type Frac.

190 > Σ > 27 gal Mpc$^{-2}$

M > 10$^{10.6}$ M$_\odot$

Σ > 190 gal Mpc$^{-2}$

M > 10$^{10.6}$ M$_\odot$
Conclusion

- Hardly any evolution in Morphology density relation for mass selected sample (Mstar $>10^{**10.6}$)
- How about the field?
Conclusion

- Morphology-density relation does not evolve strongly
- But galaxies evolve in density, mass -> they evolve along this relation
Z = 0 - 1.2  
z = 2 - 20
Do we have mass-selected sample at $z > 2$?
log(Stellar mass)

log(1700 Angstrom luminosity)
Here: select $z > 2$ galaxies in rest-frame optical

- Requires deep J, H, K-band imaging (up to 30 hours with VLT)

Main advantage:
- Selection similar to $z < 1$
- Closer to a mass selected sample

Main disadvantage:
- Use photometric redshifts
Available Surveys:

- **FIRES**: HDF-South + MS1054
  - 2.5’x2.5’
  - 5’x5’
  - VLT

- **GOODS**: CDF-South 10’x15’
  - VLT

- **MUSYCYC** near-IR: 10’x18’ + 10’x10’
  - CTIO-4m
$2 < z < 3$
Distant Red Galaxies at $z > 2$: $J - K > 2.3$
DRG  Age = 1.5 Gyr, $A_v = 2.5$
Average SED of Lyman Break
Restframe U-V color distribution
Conclusion

- At massive end, red galaxies dominate the galaxy population at $z=2-3$ ($\sim 77\%$ by mass)
- The range in luminosities and colors is very large!
  - Median J-K = 2.49
  - Median R = 25.9!

(van Dokkum et al 2006)
$J - K$

$J - K_s$

$R_{ab}$
Why are these galaxies red?

- Quiescent? [low star formation]
- Young and Dusty? [implies high SFRs]

Difficult to distinguish without additional information
Obtain Near-IR spectroscopy

- Hard – long integration times, low multiplex
- Kriek et al.: obtained spectra of 36 galaxies with GNIRS on Gemini
- K band selected – much closer to mass selection
- Unique: J,H,K in one shot!
2 hour exposure
SSFR = $0.00^{+0.41}_{-0.00} \times 10^{-2}$ Gyr$^{-1}$

age = $508^{+297}_{-0}$ Myr

$A_v = 0.7^{+0.2}_{-0.0}$ mag

$\tau = 20^{+80}_{-10}$ Myr

$\chi^2 = 1.26$

$z_{\text{fit}} = 2.63^{+0.09}_{-0.09}$
Analyze galaxies with 2<z<2.7

- 9 out of 20 no H-alpha emission line
- 2sigma upper limit EQW around 10 Angstrom
- Specific Star Formation Rate SFR/M < 10^{-10} - 10^{-11} /yr
Several indicators show

Significant fraction (40 % ± 10%) of quiescent galaxies

Others star forming with reasonably high star formation rates
General size evolution
size as function of L, M, normalized to Sloan

Trujillo et al 06
Size as function of I-K and Mass
Structure of red galaxies

Nicmos imaging of HDF-South

Zirm et al 06
Quiescent galaxies

- Low specific SFRs
- Very compact and dense -> formed very early ? (z=5 ?)
Conclusions

• Mass selected samples are required
• Massive galaxies show a wide range in properties to $z=3$
• strong evolution in number density
  -> galaxies DO evolve
To do:

- Go deeper, wider
  WF3, VISTA, JWST
- Get spectroscopy for large samples
  8-10m ? ALMA, JWST
- Get real masses
  8-10m ? ALMA, JWST
end