Extremely compact massive quiescent galaxies at \(z \sim 2.5\)

Sune Toft (ESO)

A correlation between size and star formation at \(z \sim 2.5\)
Morphologies in the local Universe

Morphology scales with:
- Density
- Star-formation
- Age
- Metallicity
- Mass

Motivation:
Push simultaneous studies of star formation and morphology to higher redshift
Data

- **NICMOS (1.5h) + ACS (12h)**
  - 41 galaxies $2 < z < 3.5$
  - 27 DRGs ($J-K > 2.3$), 14 DBGs ($J-K < 2.3$)

- **FIRES MS1054-03 catalog:**
  - U-K band photometry + photo-z’s

- **IRAC imaging**
  - (3.6 hours in 3.6, 4.5, 5.8, 8.0 $\mu$m)

- **MIPS imaging**
  - (1 hour at 24 $\mu$m)

**Morphologies**
- SB-profiles
- Sizes

**SED fits**
- Mass, SFR
- Dust, Age

**LIR**
- SFR/AGN
Properties of DRGs

- \( J-K>2.3, \langle z\rangle=2.5 \)
- UV faint, evolved stellar pops
- Highly clustered, dominate
- \( \langle M\rangle \sim 2 \times 10^{11} M_{\odot} \)
- Dominate bright end of LF
- 35% quiescent, 65% star forming

Likely progenitors of elliptical galaxies

Blue galaxies (DBGs): \( J-K<2.3 \)
Lower M, SFR, Av

\( (\text{ván Dokkum et al}) \)

\( (\text{Kriek et al}) \)
$J-K > 2.3, \ z > 2$
J-K > 2.3, z > 2

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J-K < 2.3, z > 2
J-K < 2.3, z > 2
2D surface brightness profiles

Sersic profile:

\[ I(r) = I(0) \exp \left[ b \left( \frac{r}{re} \right)^{1/n} \right] \]

- \( n \): Sersic index
- \( re \): effective radius

- \( n = 1, 2 \): “Exponential disk”
- \( n = 3, 4 \): “de Vaucouleurs”

DRGs vs DBGs

>80% Exponential disk
Sizes: DRGs vs DBGs

Normalized by SDSS Mass-re relation

Similar

Normalized by SDSS Mass-re relation
Star forming vs Quiescent

67%

Star forming

Quiescent

33%

sSFR>0.01/Gyr

sSFR<0.01/Gyr
Star forming/Quiescent n-distributions

Similar

Star forming vs quiescent’
Star forming vs Quiescent DRGs+DBGs
Sizes Star forming vs Quiescent

Different
Different

Normalized by SDSS Mass-size relation

Quiescent galaxies are smaller than star forming galaxies
Mass-Size relation

Normalized by SDSS relation
Quiescent galaxies are small, and do not host AGN
MIPS 24μm detections

Normalized by SDSS Mass-size relation

(MIPS 24μm not sensitive to PAH features beyond z>2.5)
Surface mass density

$$\Sigma_{50} = \frac{M / 2}{\pi \times r_e^2}$$

Normalized by SDSS relation
\[ \log(M) = 2\log(\sigma_v) + \log(re) + 6.07 \]
Kormendy relation

$$\langle \mu_e \rangle_B = M_B + 5 \log(r_e) + 2.5 \log(2\pi)$$
Summary

- Correlation between star formation activity and size at \( z=2.5 \)
- Star forming galaxies are detected by MIPS, quiescent are not (i.e not dominated by AGN)
- Sersic \( n \) does not correlate with SFR of J-K: Majority of massive galaxies have exponential disk profiles.
- Actively star forming galaxies a factor of \( \sim 2 \) smaller than local galaxies of similar mass
- Quiescent galaxies a factor of \( \sim 5 \) smaller than local galaxies of similar mass
Formation of quiescent galaxies
Early gas rich mergers? (e.g. Khockfar & Silk 2006)

Evolution of quiescent galaxies
Need to “puff up” sizes, without adding too much mass or new star formation
Dry merging? (e.g. Boylan-Kolchin et al. 2006)

Evolution of star forming galaxies
Gravitational infall of gas? (e.g. Bouwens & Silk 2002, Sommerville et al 2006)
The end