Many-color surveys for studying the evolution of galaxy parameters

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Many-Color Surveys
for studying the
Evolution of Galaxy Parameters

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COMBO-17/GEMS:
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FIRES:
M. Franx, I. Trujillo, I. Labbe, G.
Rudnick, N. Schreiber, et al.
Galaxy Parameter Relations

- Fundamental Plane
- Luminosity – Size Relation
- Color–Magnitude Relation
- Density – Morphology Relation

Questions for this talk:

At $z \sim 0$, most very luminous galaxies are red and dead. For how long has that been the case?

Did galaxies grow inside–out?
What type of data do we need?

We need data to $z_{\text{max}}$ that address both

- population properties: LF, MF, clustering..
- Internal structure: size, B/D, morphology..

$$p(L, \text{size, environment, } z) \Rightarrow N_{\text{galaxy}} > 10^4$$

or

if $N_{\text{galaxy}} \sim 10^{2-3}$, ask simple questions

..field size well in excess of the correlation length
COMBO-17

Co-PI’s: Chris Wolf (MPIA→ Oxford), Klaus Meisenheimer (MPIA) +MPIA+Edinburgh+Bonn+Oxford

Idea: very low resolution spectra of ‘everything’ (to $m_r \sim 23.5$) in five large fields (30’x30’)

Data: 2000–2002 with the WFI @ MPG/ESO 2.2m on La Silla Imaging in 5 broad- and 12 medium-band filters

Primary Science Goals:
- Faint AGN survey (e.g. Wolf et al 2003)
- Galaxy population to $z \sim 1.2$ (Wolf et al 2002, Bell et al 2003, Borch et al 2003)
- Weak lensing (Gray et al 2002, Kleinheinrich et al 2003)
COMBO-17 Technique

Fit SED and $z$ simultaneously
Wolf et al 2001
\[ \delta z \approx 0.015 \]
works well to $z \approx 1.1$

Example: 30'x30' field

**COMBO-17 status** (Wolf et al 2002)
3 fields complete (incl. CDF-S)
~30,000 $z$'s to $m_r \approx 23.5$
2 more fields to come
Co-Moving Luminosity Density

\[ \dot{j}_\lambda \left[ \text{W h Mpc}^{-3} \text{ Hz}^{-1} \right] \]

\[ 10^{18} \]

\[ 10^{20} \]

\[ 0 \]

\[ 0.5 \]

\[ 1 \]

Z

\( \text{r} \)

\( \text{B} \)

\( \text{280nm} \)
Massive Galaxies:
A quick Tour through Redshift Space

CDF–S/GOODS    Abell 901    S11 (random)
In the local Universe, SDSS and 2dF find a bimodal distribution of galaxy colors.
Population Evolution vs
Galaxy Evolution
in COMBO-17

The distribution of galaxy colors
Bell et al 2003

Note:
sample represents volume average also for the red galaxies
COMBO-17: Galaxy Colors
The (Red) Color-Magnitude Relation

The CMR zero-point evolution is consistent with passive aging of ancient stellar populations.

Volume averaged!

Consistent with cluster results e.g. Franx, van Dokkum
Luminosity density in red-sequence galaxies is constant

But: colors redden towards present

→ Stellar mass in red sequence grows (factor ~2)
Extended-CDFS

Non-proprietary data with ACS on HST
Sep 02 - March 03

V and z (F606W and F850LP)

m_V ~ 28.2  m_z ~ 27.1  (5σ)

~150 HDFs

Largest HST multi-band mosaic
What’s the Structure and Morphology of Red Sequence Galaxies?

“Red” galaxies red because of:
- Old population (→ massive)?
  → concentrated?
- Interacting/merging (→ dusty?)
- Edge–on

Pick thin redshift slice to eliminate
- differential band-shifting
- differential $(1+z)^4$ dimming

Visual classification vs Sersic index

85% of red sequence is early types
Bell et al 2003
Astro/ph
How did the Luminosity-Size Relation of Red Sequence, Concentrated Galaxies Evolve?

D. McIntosh et al 2003 (in prep.)

\[ L(z \mid r_e) \text{ matches color evolution} \]

Small red-sequence galaxies fade faster → last SF more recent?
How did the Size of Galaxies Evolve?

Measures:
- size function
- luminosity (or mass) vs. size relation

Local estimate:
Averaged over all types!

Shen et al 2003, SDSS
Constraining Size Evolution to z~3
Trujillo et al 2003

FIRES:
- HDFS so far
- 0.35µ–2.2µ imaging
- 0.45” resolution in J/H/K
- $T_{epx}(NIR)>30$ h /band
- K–band selected sample
- Photo–z
- Estimate $M_*$ from SEDs

→rest-frame optical sizes at all z
→most objects resolved

Three-Colour Image of the Hubble Deep Field-South (VLT ANTU/ISAAC + HST/WFPC2)
Rest-frame Optical Size Distribution
Trujillo et al. 2003

\[ R_e(M_*) \sim \text{const.} \]
Conclusions

• The most massive galaxies are red (and dead) to z~1

• L(z) and U−V(z) of bright red−sequence galaxies (volume average!) suggest passive fading of their populations since z>1

• Stellar mass in red sequence has grown by 1.5−2 since z~1
  ◆ Fading into red sequence at the faint end?
  ◆ Red−red merging at the bright end?

• Size of galaxies at a given stellar mass has hardly changed since z~3
  ◆ Evolution along M∗~r_e relation?