Introduction

The nature of the most compact galaxies and their evolution is the subject of a wide range of observational and theoretical studies (e.g., [1]). Determination of the fraction of local samples that have evolved beyond the field-expected redshift range is critical to understanding the evolution of the local galaxy population. This fraction, which is derived from the comparison of the observed fraction of galaxies with the expected fraction from the local field-selection function, provides a measure of the fraction of galaxies that have undergone significant evolution since the time of selection.

To make a more accurate comparison, it is important to consider the fraction of galaxies that have undergone significant evolution since the time of selection. This is done by comparing the observed fraction of galaxies with the expected fraction from the local field-selection function. The observed fraction is derived from the comparison of the observed fraction of galaxies with the expected fraction from the local field-selection function. The observed fraction is derived from the comparison of the observed fraction of galaxies with the expected fraction from the local field-selection function. The observed fraction is derived from the comparison of the observed fraction of galaxies with the expected fraction from the local field-selection function. The observed fraction is derived from the comparison of the observed fraction of galaxies with the expected fraction from the local field-selection function.
the faint blue galaxies are low-mass stellar systems experiencing their initial
starburst at redshifts $z \leq 1$, some of which turn into the present population of
spheroidal galaxies (Sph), such as NGC 205 (Babul & Ferguson 1996). Given
their likely starburst nature, faint blue galaxies may also be major contributors
to the global star formation rate (SFR) density already found to increase with
lookback time to at least redshift $z \approx 1$ (Cowie et al. 1995, Lilly et al. 1996).

In this project we investigate the ideas above on the nature of the faint blue
galaxies by comparing the scaling-laws of distant low-mass starbursts to those
of nearby galaxies. The goals are: to identify their local counterparts, to assess
their evolution with look-back time, and to study their role on the star formation
history of the universe. A full description of the results summarized here can be
found in Koo et al. (1995), Guzmán et al. (1996,1997), and Phillips et al. (1997).

2 The Data

The galaxy sample consists of 51 compact galaxies selected from I814 HST images
of the flanking fields around the Hubble Deep Field (HDF; Williams et al. 1996).
These objects are compact in the sense that they have small apparent half-
light radii ($r_{1/2} \leq 0.5$ arcsec) and high surface brightnesses ($\mu_{814} \leq 22.2$ mag
arcsec$^{-2}$). With no color information, the “compactness” criterion optimizes
the selection of dwarf stellar systems which are likely to be low-mass starbursts.
Spectra for these objects were obtained using LRIS at the Keck telescope with
a slitwidth of 1.1 arcsec and a 600 l/mm grating. The effective resolution is
$\sim 3.1$ Å FWHM. Typical exposure times were 3000s. The total spectral range is
$\sim 4000-9000$ Å. In addition, we obtained two 300s direct V-band exposures with
LRIS in order to provide some color information. Our final data set includes:
redshifts, $V_{606}-I_{814}$ colors, absolute blue magnitudes ($M_B$ , half-light radii ($R_e$),
surface brightnesses ($S_B_e$), velocity widths ($\sigma$), masses ($M$), mass-to-light ratios
($M/L$), $O[III]/H\beta$ line ratios, and SFRs.

Of the 51 galaxies, 6 (or 12%) show absorption-line spectra characteristic of
eLLiptical and S0 galaxies, while the remaining 45 (88%) exhibit prominent oxygen
and/or Balmer emission lines and blue continua characteristic of vigorous star-
forming systems or narrow-line active galaxies. Most of the emission-line objects
are very blue with nearly constant $V_{606}-I_{814} \sim 0.9$, while those with early-type
spectra form a reasonably tight red sequence just blueward of the color track
expected for non-evolving elliptical galaxies (Figure 1). Hereafter we focus our
study on the emission-line compact galaxies. For convenience, we divide this
sample into intermediate- ($z < 0.7$) and high-redshift ($z > 0.7$) samples.

3 Scaling-Laws

The global structural properties of galaxies can be adequately described using
the $M_B - S_B_e$ and $R_e - \sigma$ diagrams. In these diagrams, various galaxy types
define distinct correlations, albeit with large scatter (Figures 2a and 2b). Most
evolution of the global SFR with redshift, although this result should be taken with caution. A likely cause of the apparent link of passive/sdredshifts in the evolution of the universe may be the presence of a significant amount of gas in the volume sampled in both samples, which can dominate the expected SFR in the early universe. However, this is not tied to a volume-limited sample, as the universe is expanding and the volume sampled changes. Therefore, caution is advised not to place too much emphasis on the results of this study.
and dark structures. The redshifts adopted in our classification and dark structures. The redshifts adopted in our classification.

Fig. 3: $M_B$ of HDF versus $M_B$. The dotted line represents the division between HI- and H$_2$-rich galaxies. The dashed line represents the approximate location of spiral galaxies. The solid line represents the approximate location of elliptical galaxies. DANS: Dwarf Amorphous Nuclei Satellites; SHS: Starburst Nuclei; SA: Spiral. Scatter 7.

Fig. 2: (a) $M_B$ versus $M_B$. Local E, S and S models from Catinella et al. (1999):

$M_B = 10^0$ L$_\odot$, $M_B = 10^3$ L$_\odot$, $M_B = 10^6$ L$_\odot$, and $M_B = 10^9$ L$_\odot$. The dotted line represents the division between spiral and elliptical galaxies. The solid line represents the approximate location of spiral galaxies. The dashed line represents the approximate location of elliptical galaxies. DANS: Dwarf Amorphous Nuclei Satellites; SHS: Starburst Nuclei; SA: Spiral. Scatter 7.
with caution given the small number of galaxies involved in this analysis.

4 Discussion

Distant compact emission-line galaxies are young, low-mass star-forming systems. Unless reiglited by new star formation, they should fade within a few Gyr. The issue of fading and transformation of one galaxy class to another is quite complex. Perhaps one of the most useful tools we have to study how distant young galaxies relate to nearby evolved stellar systems is the $R_e - \sigma$ diagram, since neither $R_e$ nor $\sigma$ depend strongly on the fading of the stellar population. Although there are several physical processes that may modify these parameters during galaxy evolution (see Figure 2b), we find no evidence against the idea that HII-like compact galaxies (most of those with $M < 10^{10} M_\odot$) are related structurally and kinematically to the nearby population of Sph and Irr galaxies. Their evolution into one galaxy class or another may depend critically on their ability to retain part of their interstellar medium in the likely event of starburst-driven galactic winds. The extremely low mass-to-light ratios of HII-like compacts (i.e., $M/L \sim 0.3$ solar) suggest that the kinetic energy supplied by the current starburst is large enough, compared to their binding energy, to blow out most of the gas, thus preventing future star formation. Without additional star formation, galaxy evolution models predict that these low-mass starbursts will fade enough to match the low luminosities and surface brightnesses of Sph galaxies (see Figure 2a). We thus conclude that a class of HII-like, faint blue galaxies may actually be among the progenitors of today's spheroidals.

The compact galaxy sample is also useful to investigate the role of low-mass starbursts on the evolution of the SFR density at redshifts $z < 1$. In Figure 4, we show a current overall picture of the evolution of the SFR density with redshift. The interpretation of this figure should be approached with caution, given the likely differences in the calibrations for the various SFR tracers, incompleteness of the data sets, and uncertainties in the models. Despite these caveats, most of the results summarized in this figure imply that the total SFR density of the universe decreased by a factor of $\sim 10$ from $z \sim 1$ to the present-day. Assuming our sample is representative of the general population of compact galaxies, we estimate that the total SFR densities associated to this class are: $0.004 M_\odot$ yr$^{-1}$ Mpc$^{-3}$ at $z=0.55$, and $0.008 M_\odot$ yr$^{-1}$ Mpc$^{-3}$ at $z=0.85$. These values, when compared to a similar sample of local galaxies, support a similar decline in the SFR density in the last $\sim 8$ Gyr. From the comparison with the SFR densities derived by Cowie et al. (1995), we conclude that compact emission-line galaxies, though only $\sim 20\%$ of the general field population, may contribute as much as $\sim 45\%$ to the global SFR of the universe at $0.4 < z < 1$.

Acknowledgements. This project is a collaborative effort of the DEEP team at UC Santa Cruz (http://www.ucolick.org/~deep/home.html). R. Guzmán would like to thank the organizing and scientific committees for their kind invitation
Fig. 4. SFR density vs. redshift. Filled circles are the estimates for compact galaxies. These values should be compared to the open circles labelled “Int-z” and “High-z”, which represent the values for similar samples of nearby compact galaxies. Dotted lines represent Pei & Fall’s models (1995). The dashed line represents the fiducial value. We adopt H0 = 50 km s⁻¹ Mpc⁻¹ and q₀ = 0.5.

and financial support to participate in this excellent meeting. Funding for this project is credited to NASA grants AR-06337.08-94A, AR-06337.21-94A, GO-05994.01-94A, AR-5801.01-94A, and AR-6402.01-95A from the Space Telescope Institute and NSF grants AST 91-20005 and AST 95-29098.

References

Ellis R.S., 1996, in ESO Workshop on The Early Universe with the VLT, in press