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CENSUS OF THE STAR-FORMING GALAXY POPULATION AT $Z < 1.5$

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RESUMEN

Una cuestión clave en la evolución de galaxias es la naturaleza física de galaxias de corrimiento al rojo intermedio y de sus actuales contrapartes. Se sabe que la densidad de la tasa de formación estelar se incrementa rápidamente desde $z = 0$ a $z = 1 - 2$. Sin embargo, el tipo de galaxias que contribuye al incremento de la densidad de formación estelar se encuentra todavía en debate. En principio, una función de luminosidad muy inclinada donde la mayor parte de formación estelar está comprendida en galaxias enanas de reciente formación, o en poblaciones de galaxias masivas que están pasando por formación estelar modesta pero contínua, pueden producir una tasa de densidad de formación de estrellas similar a un corrimiento al rojo dado. Por lo tanto, es necesario un censo de la población de galaxias con formación estelar como una función del tiempo para ayudarnos a entender mejor cómo las galaxias adquirieron su morfología actual.

ABSTRACT

A key question in galaxy evolution is the physical nature of the intermediate redshift galaxies and their present-day counterparts. It is known that the star formation rate density increases rapidly from $z = 0$ to $z = 1 - 2$. However, the type of galaxies that contribute to the rise of the star formation density is still debatable. In principle, a steep luminosity function where most of the star-formation is in newly-formed dwarf galaxies or a population of massive galaxies undergoing modest but continuous star formation can produce similar star-formation rate density at a given redshift. Therefore, a census of the star-forming galaxy population as a function of time is needed in order to help us better understand how galaxies acquired their present morphology.

Key Words: **GALAXIES: EVOLUTION — GALAXIES: FORMATION — GALAXIES: STARBURST**

1. INTRODUCTION

Star-forming galaxies at high$-z$, known as Lyman Break Galaxies (LBGs), are easily identified using the Lyman break technique (e.g. Steidel et al. 1995). LBGs are UV–luminous and thought to be similar to local starburst galaxies, they are relatively small (r_h=1-3 kpc), have relatively low mass ($10^{9.5-11}M_\odot$) and low extinction. However, their role in galaxy evolution is still debatable. Do all galaxies go through a Lyman Break phase? How biased is our view of galaxy evolution due to the Lyman break technique? are LBGs the building blocks of larger systems or are they just small galaxies having their first burst of star-formation? Interestingly enough, finding unobscured star-forming galaxies in the intermediate redshift range ($0.5 < z < 1.5$) is not as simple as finding them at higher–z, since the UV light ($\lambda \sim$ 1000–2000 Å) that comes from young and massive OB stars is redshifted into the near–UV. The near–UV detectors are less sensitive than optical ones which makes UV imaging expensive in telescope time. For instance, ∼30% of HST time in the Hubble Deep Field campaign was dedicated to the U-band (F300W – $\lambda_{\rm max}$ = 2920 Å), whereas the other 70% was shared between B, V, and I-bands. Despite of this, the limiting depth reached in the U-band is about a magnitude shallower than in the other bands, i.e. deep near–UV coverage with HST is rare. In this contribution I summarize the results of the UV coverage of the Great Observatories Origins Deep Survey (GOODS, Giavalisco et al. 2004) done with HST's WFPC2/F300W (de Mello et al. 2004, 2006, Wadadekar et al. 2006).

2. THE SHALLOW UV DATA

A total of 741 WFPC2 images were obtained during the GOODS campaign covering ∼ 88% of the two fields. The drizzled images are relatively shallow with typical exposure time of ∼2,000s and reaching $\rm mag_U < 24.5$. We detected sources on the drizzled images (SExtractor v2.2.2, Bertin & Arnouts 1996) and matched the WFPC2 U–band catalog with the ACS B–band catalog produced by the GOODS team. We identified a total of 130 objects in the GOODS-S and 138 in the GOODS-N. Photometric redshifts were calculated using the template fitting method described in detail in Dahlen et al. (2005). The templates SEDs used cover spectral types of E, Sbc, Scd and Im (Coleman et al. 1980, with extension into

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UV and NIR-bands by Bolzonella et al. 2000), and of two starbursts (Kinney et al. 1996). The analysis of the GOODS/ACS images of these UV–selected objects reveals that:

1. Most of the UV–selected objects have $0.2 < z < 0.8$ and have spectral types of starbursts. However, galaxies of all spectral types are found, including early–types (5%),

2. 75% of the starbursts have tidal tails or show some peculiarity typical of interaction/mergers and 50% of the starbursts have another galaxy within 5×5 arcsec;

3. The bluest galaxies ($U - B < 0.2$ and $B - V < 0.1$) are at $1.1 < z < 1.9$ and have peculiar morphologies that resembles either tadpoles, chains, or double-clump galaxies.

4. The UV–selected sample has an average rest-frame M_B=19.9 $\pm$ 0.1 which is at least two magnitudes fainter than typical LBGs. However, their half-light radius (1.63 ± 0.37 kpc) is comparable to LBGs sizes (Pettini et al. 2001).

Although these results summarize the nature of the objects that are UV–sources in the intermediate–z universe, the data used are biased toward bright objects due to the low exposure times. This motivated us to analyze the deepest UV data ever taken with HST described below.

3. THE DEEP UV DATA

In parallel to the ACS Ultra Deep Field other instruments aboard HST also obtained deep images. We analyzed the portion of the data taken with the WFPC2 (F300W) which falls within the GOODS–S field. The data are $\sim$ 1 magnitude deeper than the original deep fields. Although only slightly larger than one WFPC2 field, 415 objects were identified by SExtractor due to the depth of the data (Wadadekar 2005, de Mello et al. 2006, Wadadekar et al. 2006). The main results are as follows:

1. UV–selected galaxies span all the major morphological types at $0.2 < z < 1.2$. However, disks are more common at lower redshifts, $0.2 < z < 0.8$.

2. Higher redshift objects ($0.7 < z < 1.2$) are on average bluer than lower$-z$ and have spectral type typical of starbursts. Their morphologies are compact, peculiar or low surface brightness galaxies.

3. Despite of the UV–selection, 13 objects have spectral types of early–type galaxies; two of them are spheroids with blue cores.

4. The majority of the UV–selected objects have rest-frame colors typical of stellar populations with intermediate ages > 100 Myr.

5. Although similar in sizes, the UV–selected galaxies are on average less luminous than LBGs.

We have inspected all galaxies which are in the GOODS images and not in the U-band (U-dropouts) and classified their morphology using an empirical classification scheme. Objects that appear to be single and compact are classified as clumps (1), double or multiple clumps (chains) are classified as (2), clumps with tails, i.e. tadpoles as (3). Objects which are not compact but extended and fuzzy are classified as (4), and fuzzy extended objects but with a more organized disk-like are classified as (5). For our sample, the fraction of single clumps is similar to the fraction of fuzzy objects ($\sim$ 35%), however if double clumps and tadpoles are included in the clump class (1), this fraction increases to $\sim$60%. These objects could be accreted clumps that are building up galaxies through hierarchical mergers or clumpy disks (Elmegreen et al. 2005). Their properties and role in galaxy evolution should be further analyzed.

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