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3D SPECTROSCOPY OF LUMINOUS COMPACT BLUE GALAXIES

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RESUMEN

Las galaxias luminosas compactas azules (LCBGs) son galaxias de elevado brillo superficial, más azules que una SBc típica y más brillantes que $0.25L^{\star}$, que experimentan en la actualidad un violento brote de formación estelar. Las LCBGs representan el homólogo más cercano a la abundante población de galaxias *starburst* a z alto e intermedio, entre las que se incluyen las galaxias *Lyman-break* a $z \sim 2$. Hemos seleccionado una muestra pequeña, aunque representativa, de 24 LCBGs de los catálogo de SDSS, UCM y MRK, que no sólo nos brinda la posibilidad de caracterizar esta población, sino que además nos permite compararla con presentes y futuros estudios de galaxias *starburst* similares a alto z. Estamos llevando a cabo un estudio de espectroscopía óptica 3D como parte de un ambicioso análisis en varias longitudes de onda que abarca desde ultravioleta lejano (GALEX) hasta radio (VLA). La espectroscopía 3D proporciona mapas de velocidad, extinción, tasa de formación estelar y metalicidad con el fin de caracterizar la historia de la formación estelar y la distribución de la masa, así como el papel que juegan en dichas galaxias fusiones y vientos galácticos de supernova. Aquí presentamos los primeros resultados de nuestro estudio a partir de datos obtenidos en el telescopio de 3.5-m en CAHA. Estos datos son utilizados además para simular espectros ópticos integrados de galaxias *starburst* a alto z tal y como se verían a través de la nueva generación de espectrógrafos infrarojos multiobjeto, tales como EMIR en GTC.

ABSTRACT

Luminous Compact Blue Galaxies (LCBGs) are high surface brightness galaxies, bluer than a typical SBc and brighter than $0.25L^{\star}$, which are undergoing a major burst of star formation. LCBGs are the closest counterpart of the numerous population of starburst galaxies at intermediate and high redshift, including Lyman-break galaxies at $z \sim 2$. We have selected a representative sample of 24 LCBGs from the SDSS, UCM and MRK catalogs which, although small, provides an excellent reference for characterizing LCBGs as a class and for comparison with current and future surveys of similar starbursts at higher redshift. We are carrying out a 3D optical spectroscopic study of this LCBG sample as part of an ambitious multiwavelength program ranging from FUV (GALEX) to radio (VLA). 3D spectroscopy provides spatially resolved maps of kinematics, extinction, SFR and metallicity, in order to characterize their star formation history and mass distributions, and the role of mergers and supernova galactic winds. We present results from data taken with PPAK at the 3.5-m telescope in CAHA. We use these data to simulate integrated rest-frame optical spectra of high redshift starburst galaxies using the new generation of IR multi-object spectrographs, such as EMIR at the GTC.

Key Words: **GALAXIES: STARBURST**

1. INTRODUCTION

One of the key results in recent observational cosmology is the discovery of a starburst population at $z \sim 2$ using the *Lyman-break* technique (Steidel et al. 1996; Lowenthal et al. 1997). The high-z starburst population, according to the hierarchical galaxy formation paradigm, will evolve through episodes of star formation and mergers to become today's population of massive galaxies (e.g., Kauffman et al. 1999). While predicted by theory, this galaxy assembly scenario must be determined empirically. To do so we must determine the evolutionary history of four quantities: dynamical masses, stellar content, star formation rates (SFRs), and heavy elements abundances.

The *Lyman-break* technique has been known for a long time (e.g., Partridge 1974) but has only been successfully applied after the launch of the Hubble Space Telescope. Furthermore, thanks to the gathering power afforded by the 8-m class telescopes rest-frame FUV spectra were obtained with optical spectrographs (Steidel et al. 1996; Lowenthal et al. 1997). Several current major surveys pursue the characterization of the high-z starburst population using 10-m class telescopes (e.g., Steidel et

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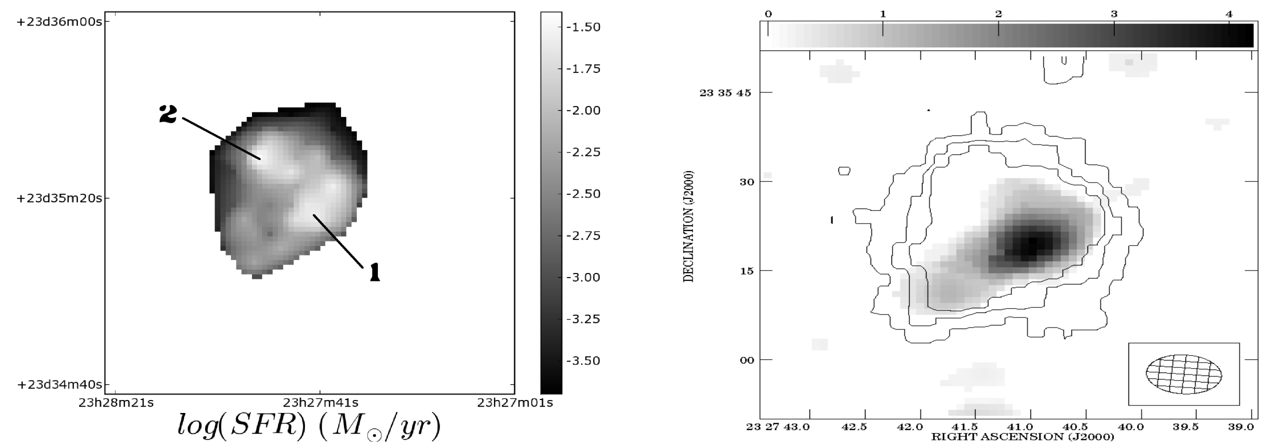

Fig. 1. (*left*) Preliminary SFR map of the LCBG UCM325 derived from H_α emission lines using PPAK data. Two main bursts are detected, a main one (1) forming stars at a rate of 3–5 $M_\odot$/yr, and a secondary one (2) forming stars at a ratio of about $1 M_\odot$/yr. (*right*) DSS optical image (contours) overlaid on a grey scale map of the CO intensity of LCBG UCM325 from which the properties of the molecular gas can be derived. While the HII seems to be located in two different regions the H_2 seems to concentrate where the main burst is.

al. 2003). Nevertheless, the tipping point will not happen until the arrival of the new generation of infrared multi-object spectrographs such as EMIR at the GTC. This will give rise to surveys such as GOYA (Balcells 2006 in these proceedings)that will systematically survey the rest-frame optical properties of the high-z galaxy population. These include abundances, H_α luminosities, extinction, and kinematics. A different approach is to thoroughly observe their closest local counterparts.

Luminous Compact Blue Galaxies (LCBGs) are blue ($(B-V) < 0.6$), high surface brightness ($SB_e <$ 21 mag arcsec^{-2}), vigorously starbursting galaxies with $M_B < -18.5$, assuming $H_0 = 70$ km s^{-1} Mpc^{-1} (Garland et al. 2004). LCBGs are the closest counterpart of high-z starbursts and they share not only a similar range in M_B, SB_e and $(B-V)$, but also metallicities close to solar value, sizes ranging between 2 and 5 Kpc, SFRs around 10–20 $M_\odot$/yr, velocity widths of 30–120 km s^{-1}, and a wide range of morphologies (Guzmán et al. 1997; Pettini et al. 2001; Erb et al. 2003; Siegel et al. 2005). Hereafter, we call them all LCBGs, whether at low-, intermediate-, or high-z.

Current observational studies highlight the key role that LCBGs play in galaxy evolution over cosmological time-scales. LCBGs (i) contribute the most to the evolution of the blue $\sim L^\star$ galaxies in the last ~ 8 Gyr (Lilly et al. 1998); (ii) are a major contributor to the observed increase in the star formation rate density of the universe at $z < 1$ (Guzmán et al. 1997); and, as stated above, (iii) may be lower mass counterparts of the star-forming population at $z \sim 2$.

2. PROJECT OVERVIEW

We have selected a representative sample of 24 LCBGs within 100 Mpc from the SDSS, UCM (Zamorano et al. 1994), and MRK catalogs that best resemble the characteristics of the distant starburst population. This sample, although small, is representative of the LCBG galaxy population as a class in terms of M_B, $(B-V)$, scenario (isolated or interacting), and spectroscopic type (HII- or SB disk-like, Guzmán et al. 1997).

This representative sample allows us to produce a complete multiwavelength characterization of the nature of the nearby LCBG population from FUV (GALEX) to radio (VLA), which does not exist to date. Our study not only includes the obvious physical properties of the gaseous component (i.e., neutral, molecular and ionized hydrogen gas, Figure 1, Garland et al. 2004,2005,2006; Pisano et al. 2006), but the link of these to those of the underlying, older stellar component. The physical properties of this component can be parametrized through observations of optical absorption lines indices which provide measurements of the velocity dispersion, rotation, age, and metallicity of the stellar content.

It is the 3D optical spectroscopy that is the most important aspect of our study. Using PPAK at the 3.5-m telescope in CAHA we are able to produce spatially resolved maps not only of the kinematics of the ionized gas and SFR, as shown in Figure 2, but also

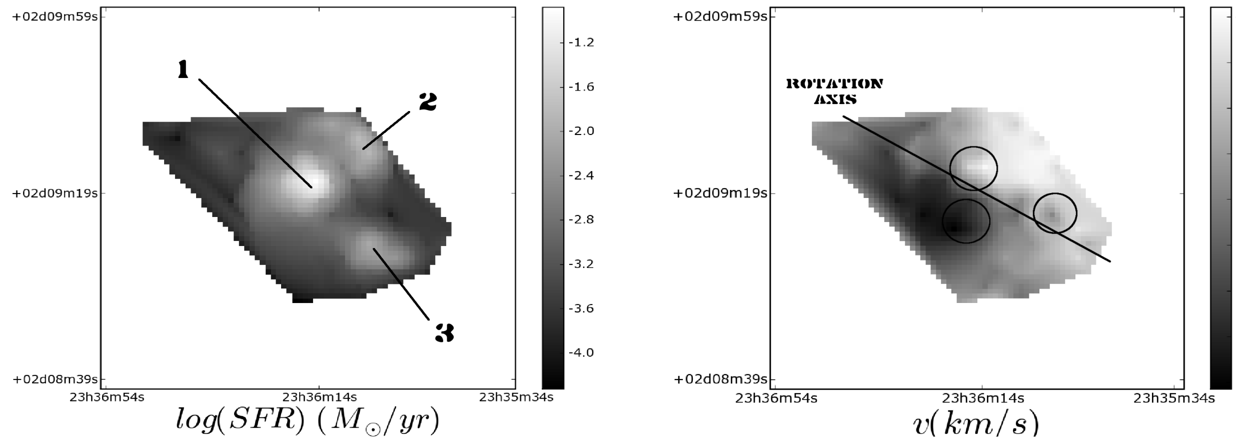

Fig. 2. (*left*) Preliminary SFR map of LCBG MRK538 derived from H_α emission lines using PPAK data. Three main regions of star formation are shown. A main burst (1) in its center which is forming stars at a rate of about 10 $M_\odot$/yr and two secondary burst (2,3) forming stars at lower rates. (*right*) Preliminary velocity map of LCBG MRK538 derived from H_α lines using PPAK data. Asymmetries as the ones shown as examples (circles) are common in this kind of galaxies. The velocity field cannot be fit by a single rotation implying the presence of extra kinematic components.

of extinction and metallicity. 3D maps allow us to test model predictions on the origin and evolution of these starburst galaxies including the role of mergers and supernova galactic winds (cross-correlating kinematic and morphological information), and the star formation history (via age/metallicity measurements of the various stellar components).

The wide field of view of PPAK, as well as its good spatial and spectral resolutions, is optimum for the observations of our sample of galaxies with typical half-light diameters of 10–30 arcsec, and velocity widths of 30–120 km s^{-1}. Furthermore, PPAK optical data can be used to simulate high-z observations of LCBGs.

3. CONCLUSIONS

In this conference we have presented the first results of a thorough study of LCBGs in the local universe (Pérez-Gallego et al. 2006; Castillo-Morales et al. 2006). This study, and in particular the 3D optical spectroscopy of local LCBGs, will both uniquely define the LCBG population as a class and provide a key reference for comparison with rest-frame optical studies of similar starburst galaxies at high redshift, such as Lyman-break galaxies, using the new generation of near infrared spectrographs in 10-m class telescopes such as EMIR at the GTC.

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