The Neutral ISM in Nearby Luminous Compact Blue Galaxies

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1 Introduction

Luminous Compact Blue Galaxies (LCBGs) are \sim L^*, blue, high surface brightness, high metallicity, vigorously starbursting galaxies with an underlying older stellar population [1, 2]. They include a variety of morphological types, such as spiral, polar-ring, interacting/merging and peculiar galaxies. They have optical diameters of a few kpc, but are more luminous and more metal rich than the Blue Compact Dwarf Galaxies widely studied in the nearby Universe, e.g. [3, 4].

When Jangren et al. [5] compared intermediate redshift LCBGs with local normal galaxies, they found that they can be isolated quantitatively on the basis of color, surface brightness, image concentration and asymmetry, with color and surface brightness giving the best leverage for separating LCBGs from normal galaxies. Specifically, LCBGs have B−V < 0.6, SBe < 21 mag arcsec−2, and M_B < −18.5, assuming H_0 = 70 km s^{-1} Mpc^{-1}. LCBGs are quite common at intermediate redshifts, but by z~0 their number density has decreased by a factor of ten. At z~1, they have a total star formation rate density equal to that of grand-design spirals at that time, but today they contribute negligibly to the star formation rate density of the Universe [6]. Therefore, LCBGs must undergo dramatic evolution. From studies at intermediate redshift, Koo et al. [7] and Guzmán et al. [1] suggest that some LCBGs may be the progenitors of local low-mass dwarf elliptical galaxies. Alternatively, Phillips et al. [8] and Hammer et al. [9] suggest that others may be more massive disks forming from the center outward to become local L^* galaxies.

In order to discriminate between the possible evolutionary scenarios it is essential to measure the dynamical masses of the galaxies: Are they as massive as implied by their high luminosities? It is also essential to measure their gas content for future star formation in order to constrain the amount
of fading of their stellar populations. We have undertaken a survey of local LCBGs in H I and CO to address these questions. The H I provides a measure of the dynamical mass, while both H I and CO provide measures of the gas content: H I for long-term star formation and CO for the current burst of star formation.

2 Observations

The current sensitivity of telescopes limits us to detecting CO in LCBGs within \(\sim 70\) Mpc. We used the first data release of the Sloan Digital Sky Survey to select our sample of nearby LCBGs, using Jangren et al.’s [5] selection criteria. Out of the \(~\)million galaxies in the first data release, only \(~\)100 are LCBGs, and only 16 are within 70 Mpc. To these 16 local LCBGs, we added four more from the literature, for a local LCBG sample of 20 galaxies. We observed this sample in 21 cm H I using the Green Bank Telescope at the National Radio Astronomy Observatory in Green Bank, West Virginia in Winter 2002. The James Clerk Maxwell Telescope on Mauna Kea, Hawai’i was used to observe our sample in CO(J=2−1) in 2002 - 2003. All sources were detected in H I; 13 were detected in CO(J=2−1).

3 Results

3.1 Dynamical Masses

We find that local LCBGs span a wide range of dynamical masses, from \(4 \times 10^9\) to \(1 \times 10^{11}\) M\(_{\odot}\) (measured within \(R_{25}\)). Figure 1 compares the dynamical masses of local LCBGs with intermediate redshift LCBGs and local spiral galaxies of all Hubble types. Many local LCBGs are \(~\)ten times less massive than local galaxies of similar luminosities, as found for LCBGs at intermediate redshifts [8]. However, others are as massive as local galaxies of similar luminosities.

3.2 Gas Depletion Time Scales

We find our 13 LCBGs detected in CO(J=2−1) have molecular gas masses ranging from \(5 \times 10^7\) to \(2 \times 10^9\) M\(_{\odot}\) (assuming a Galactic CO-to-H\(_2\) conversion factor of \(1.8 \times 10^{20}\) cm\(^{-2}\) K\(^{-1}\) km\(^{-1}\) s [10]). Note that these are most likely underestimates of the molecular gas masses since we are using CO(J=2−1). The fraction of molecular to atomic gas mass is small, ranging from 0.03 to 0.3, similar to local late-type spiral galaxies [11].

We estimated star formation rates from available IRAS data, using 60 and 100 \(\mu\)m fluxes as outlined in Kewley et al. [12]. The star formation rates for local LCBGs range from \(~\)1 to 15 M\(_{\odot}\) year\(^{-1}\). For comparison, local
spirals of all types have star formation rates $\sim 2 \, M_\odot \, \text{year}^{-1}$ [11], so these LCBGs do not have unusually high star formation rates. However, they do have very high specific star formation rates—the ratio of star formation rate to dynamical mass (within $R_e$). As seen in Figure 2, local LCBGs have specific star formation rates from $\sim$3 to 40 times those of local normal spirals [11]. The specific star formation rates of local LCBGs are in the same range as local H II (starbursting) galaxies [13].

We find that the molecular gas in local LCBGs is depleted quite quickly, in 30 to 200 million years. The molecular plus atomic gas is depleted in 30 million to 10 billion years; however, $\sim$80% of the local LCBGs deplete their gas in less than 5 billion years. Therefore, most LCBGs will not be able to sustain their current rates of star formation and will eventually fade.

4 Conclusions

Both in dynamical masses and gas depletion time scales, we find that local LCBGs have a wide range of characteristics and are unlikely to evolve into one galaxy class. They have dynamical masses consistent with a range of galaxy types, such as dwarf ellipticals, Magellanic (low-luminosity) spirals and normal spirals. The majority have atomic plus molecular gas depletion time scales less than five billion years; such galaxies may have masses, sizes and faded luminosities and surface brightnesses consistent with the brightest local dwarf ellipticals. A few local LCBGs have longer gas depletion time scales, approaching a Hubble time. These may fade very little, becoming spirals or Magellanic irregulars.

Acknowledgements Support for this work was provided by the NSF through award GSSP02-0001 from the NRAO. Support for conference attendance was provided by the AAS and NSF in the form of an International Travel Grant.

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Fig. 1. Dynamical masses (within R_{25}) for local LCBGs, as measured from H I observations. For comparison, the ranges of dynamical masses for intermediate redshift LCBGs [8], and local spiral galaxies [11] are indicated. Note that “Sm” indicates Magellanic or low-luminosity spirals.

Fig. 2. The specific star formation rate (ratio of star formation rate to dynamical mass within R_e) for the local sample of LCBGs. Their specific star formation rates are much higher than all types of local spirals (S); they are similar to local H II galaxies.