The Evolution of Luminous Compact Blue Galaxies: Disks or Spheroids?

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Abstract. Luminous compact blue galaxies (LCBGs) are a diverse class of galaxies characterized by high luminosity, blue color, and high surface brightness that sit at the critical juncture of galaxies evolving from the blue to the red sequence. As part of our multi-wavelength survey of local LCBGs, we have been studying the HI content of these galaxies using both single-dish telescopes and interferometers. Our goals are to determine if single-dish HI observations represent a true measure of the dynamical mass of LCBGs and to look for signatures of recent interactions that may be triggering star formation in LCBGs. Our data show that while some LCBGs are undergoing interactions, many appear isolated. While all LCBGs contain HI and show signatures of rotation, the population does not lie on the Tully-Fisher relation nor can it evolve onto it. Furthermore, the HI maps of many LCBGs show signatures of dynamically hot components, suggesting that we are seeing the formation of a thick disk or spheroid in at least some LCBGs. There is good agreement between the HI and H\textalpha\ kinematics for LCBGs, and both are similar in appearance to the H\textalpha\ kinematics of high redshift star-forming galaxies. Our combined data suggest that star formation in LCBGs is primarily quenched by virial heating, consistent with model predictions.

Keywords. galaxies: formation – galaxies: evolution – galaxies: ISM – galaxies: kinematics and dynamics – galaxies: interactions – galaxies: starburst

1. Introduction

When the universe was 4.6 Gyr old, the galaxy population was dominated by blue, star-forming galaxies. Up to 40\% of these galaxies were luminous compact blue galaxies (LCBGs) which contribute significantly to the global star formation rate density at that time (Guzman et al. 1997). Today, the population of galaxies is roughly evenly divided between a red and a blue population and the star formation rate density has dropped by an order of magnitude. Similarly, LCBGs are an order of magnitude less common (Werk et al. 2004) and contribute negligibly to the global star formation rate (Guzman et al. 1997). LCBGs are a diverse class of galaxies characterized by their high luminosities (M_B \leq -18.5 mag), compact sizes (SBe(B)\leq 21 mag arcsec^{-2}, equivalent to r_{eff} \leq 4 kpc), and blue colors (B – V \leq 0.6 mag); they have the highest star formation rate per unit mass for high mass galaxies (Gil de Paz et al. 2000). Typical stellar masses of LCBGs are \sim 5 \times 10^{10} M_\odot, (Guzmán et al. 2003) placing them near the maximal stellar mass of
the blue sequence (Kauffmann et al. 2003). Above this mass limit, all galaxies are red so some process must quench the star formation in galaxies as they grow. There have been numerous theories as to what quenching mechanisms operate in galaxies on the blue sequence. These include the shock heating of gas to the virial temperature (Cattaneo et al. 2006), or heating by starbursts by supernovae- or AGN-driven winds or some combination of multiple processes (Hopkins et al. 2006, and references therein). Since LCBGs reside at the high mass end of the blue sequence, they are poised to have their star formation quenched in the near future and, therefore, represent an ideal population to study viable quenching mechanisms that could also be responsible for the emergence of a red sequence in the past 8 Gyr.

We are conducting a multi-wavelength survey, spanning the ultraviolet through the radio, of the rare, local LCBGs to constrain the viable mechanisms for quenching star formation in blue galaxies and the future evolutionary paths of LCBGs. Therefore, we have selected our LCBGs from the Sloan Digital Sky Survey (SDSS) within $D \leq 200$ Mpc to have the same properties, listed above, as LCBGs at high redshift. This yields a total of 2359 LCBGs out of over 800,000 galaxies in the SDSS DR4. Of these, we have collected single-dish HI observations of 163 LCBGs. The distribution of properties for all LCBGs are shown in Figure 1.

2. Results

Single-dish HI observations permit a direct measure of the amount of fuel available for star formation, $M_{HI}$, and, by using the linewidth and an estimate of a galaxy’s extent, the dynamical mass, $M_{dyn}$. When combined with a measure of the star formation rate, such as the non-thermal radio continuum emission or emission from dust in the far-infrared, this provides an estimate of the duration of the current starburst: $\tau = M_{HI}/SFR$.

We have used original observations and archival data from Arecibo, the Green Bank Telescope, Parkes, Nançay, and the old Green Bank 140-foot and 300-foot telescopes.
The Evolution of LCBGs: Disks or Spheroids?

The signature of ongoing spheroid formation in some LCBGs is consistent with the idea that star formation in these galaxies is being quenched via virial heating, but this is not a unique explanation. Figure 1 shows that those LCBGs with the smallest values of $V_{rot}/\sigma$ are the most compact, bluest, and highest luminosity systems. This could also indicate that quenching from heating due to the intense central starburst or its associated supernovae is a possibility. This is supported by the results of optical spectroscopy by Pérez-Gallego et al. (2011) who found that while only 5% of LCBGs have an AGN, 27% have signatures of supernovae-driven winds. The remaining LCBGs could then be quenched via virial heating. In the future, we will be expanding our HI mapping to study
Figure 2. A montage of velocity fields (left column) and maps of velocity dispersions (right column) for SDSS 0125+0110 (top row) and Mrk 325 (bottom row). Velocity field contours are every 25 km s\(^{-1}\) for SDSS 0125+0110 and every 10 km s\(^{-1}\) for Mrk 325. Contours on the velocity dispersion maps are every 10 km s\(^{-1}\) and every 5 km s\(^{-1}\) for the two galaxies, respectively. The beam size is shown in the lower left corner of each panel.

additional LCBGs with a wider range of properties and we will use multi-wavelength data to search for signatures of active quenching in LCBGs.

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The Evolution of LCBGs: Disks or Spheroids?

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