*GALAXIES IN ISOLATION: EXPLORING NATURE VERSUS NURTURE*
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# The Environment of Nearby Blue Compact Dwarf Galaxies

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**Abstract.** We are obtaining deep multiwavelength data of a sample of nearby blue compact dwarf galaxies (BCDGs) combining broad-band optical/$NIR$ and H$\alpha$ photometry, optical spectroscopy and 21-cm radio observations. Here we present H I results obtained with the *Australia Telescope Compact Array* for some BCDGs, all showing evident interaction features in their neutral gas component despite the environment in which they reside. Our analysis strongly suggests that interactions with or between low-luminosity dwarf galaxies or H I clouds are the main trigger mechanism of the star-forming bursts in BCDGs; however these dwarf objects are only detected when deep optical images and complementary H I observations are performed. Are therefore BCDGs real isolated systems?

## 1. Introduction

BCDGs are a subset of low-luminosity galaxies undergoing strong and short-lived episodes of star formation at the present time. They usually exhibit a compact, irregular morphology and display intense, narrow emission lines superposed on a blue continuum. Due to the low metallicity and the considerable gas consumption involved in the violent bursts, it is believed that, unlike spirals, the star formation in BCDGs takes place in transient, sporadic bursts. The origin and nature of their starburts is still, however, poorly understood. There is increasing observational evidence that interactions of BCDGs with dwarf galaxies trigger the star formation activity in these systems (i.e. Méndez & Esteban 2000; López-Sánchez & Esteban 2008, 2009). Optical images of BCDGs rarely show clear interaction features, but interferometric H I studies have resulted in surprises. Indeed, neutral gas is the best tracer for galaxy interactions because it is more easily disrupted by tidal forces than the stellar disk. H I observations also provide an estimate of the total dynamical mass and the neutral gas content. Combining H I data with parameters such as the absolute luminosity, star formation rate, stellar and dust content or the oxygen abundance can furnish powerful clues about the nature and evolution of BCDGs.

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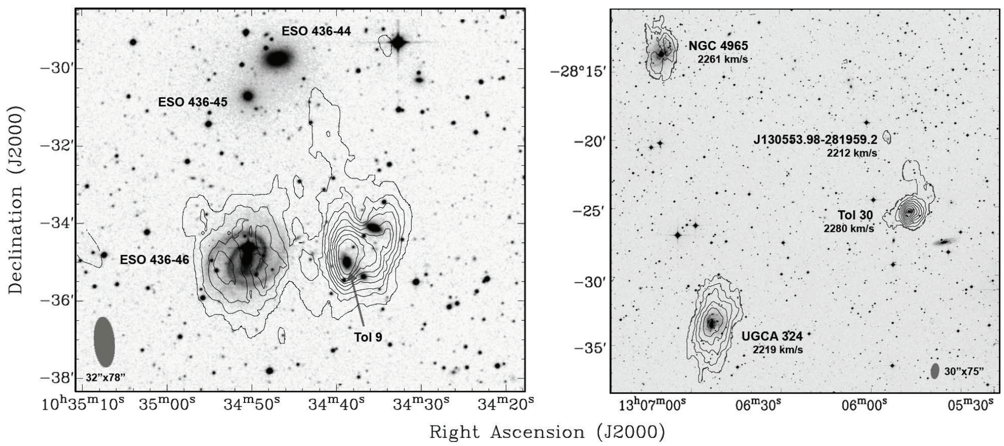


Figure 1. ATCA H I distribution of the galaxy groups associated with Tol 9 [*left*] and Tol 30 (*right*) overlaid onto an *R*-band image from the DSS.

## 2. ATCA Observations

We obtained deep multi-wavelength data of a sample of nearby BCDGs combining broad-band optical/*NIR* and H$\alpha$ photometry and optical spectroscopy with deep 21-cm radio continuum and line observations. The latter were obtained with the *Australia Telescope Compact Array* (ATCA) interferometer using full synthesis observations (12 hours) in four different array configurations. We selected 10 bright BCDGs that were detected in the H I *Parkes All-Sky Survey*, HIPASS (Barnes et al. 2001; Koribalski et al. 2004). Some BCDGs are apparently isolated (He 2-10, IC 4662, IC 4870, ESO 108-G017, POX 4), while others belong to a galaxy pair (TOL 1924-416, NGC 1510) or a galaxy group (Tol 9, Tol 30 and NGC 5253). The radio data of the galaxies NGC 1510, NGC 5253 and IC 4662 are part of *The Local Volume* H I *Survey* (LVHIS[1]). The final radio maps will be obtained by combining all available arrays, having both high sensitivity (H I column density of $\sim 5 \times 10^{19}$ cm$^{-2}$ for a 40" beam) and good angular ($\sim 20 - 30$") and velocity ($10 - 20$ km s$^{-1}$) resolution.

## 3. BCDGs in Galaxy Groups and Galaxy Pairs

One of the key points in our analysis is to compare the properties derived for BCDGs belonging to galaxy groups with those that are in pairs or apparently isolated. Tol 9 is located in the center of the Klemola 13 group, its optical properties were published in López-Sánchez & Esteban (2008, 2009). The H I map (Figure 1, *left*) shows that the neutral gas is found in two regions: one associated with the spiral galaxy ESO 436-46 and the other embedding Tol 9 and two nearby objects, revealing a long H I tail in direction to ESO 436-44 and

[1] LVHIS is a large project (Koribalski 2008) that aims to provide detailed H I distributions, velocity fields and star formation rates for a complete sample of nearby, gas-rich galaxies belonging to the Local Volume (∼10 Mpc). See *http://www.atnf.csiro.au/research/LVHIS*.

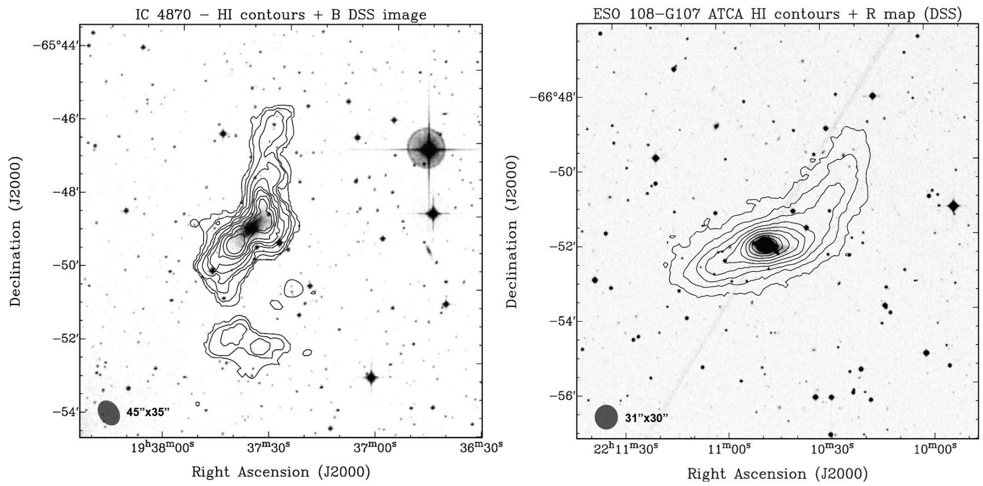


Figure 2. Preliminary ATCA H I maps of the galaxies IC 4870 (*left*) and ESO 108-G107 (*right*) overlaid onto optical DSS images.

ESO 436-45. The H I cloud in which Tol 9 and its surrounding dwarf galaxies are embedded seems to rotate as a single entity (López-Sánchez et al. 2008b). The kinematics of the tail suggest that it is of tidal origin.

Our analysis of the H I gas in Tol 30 has revealed two faint tails starting at opposite sides of the galaxy, where the brightest H II regions are located (Figure 1, *right*). The northern tail hosts around 15% of the total H I mass of the system. We detected a detached H I cloud at the NE of Tol 30 that seems to show rotation. Our deep optical images confirm the detection of an object within this H I cloud. We think it is not a tidal dwarf galaxy but an independent nearby low-luminosity dwarf galaxy that interacted with Tol 30.

The analysis of the H I kinematics in NGC 5253 reveals a velocity gradient along the optical minor axis of the galaxy; it does not show any sign of regular rotation (López-Sánchez et al. 2008a). Some authors suggested that it is an outflow. However, we think that it may be the disruption/accretion of a dwarf gas-rich companion or the interaction with another galaxy in the M 83 subgroup.

Two of the BCDGs in our sample reside in a galaxy pair. The H I map of TOL 1924-416 reveals a huge amount of neutral gas and an H I bridge towards the companion galaxy ESO 338-004B. The H I bridge has $\sim$33% of all the neutral gas and it was probably expelled from TOL 1924-416. A detailed analysis of the H I of NGC 1512 and the BCDG NGC 1510 is presented in Koribalski & López-Sánchez (2009). Our data strongly support the interaction-induced scenario to explain both the H I features and the star-formation activity in the system, that seems to be experiencing the first stages of a minor merger.

## 4. Apparently Isolated BCDGs

The optical appearance of IC 4870 shows a compact star-forming core embedded in an elliptical low-luminosity component but its H I map (Figure 2, *left*) reveals a lot of neutral gas and two long tails arising in opposite directions. We detect two maxima of the H I emission located at the beginning of the tails. The northern tail is quite straight and does not show important variations in its kinematics, but the southern tail is slightly curved towards the W. This tail possesses a knot at the south that hosts ∼14% of all the H I mass of the system and shows a velocity gradient. All these facts suggest that IC 4870 is experiencing a merging of two independent H I clouds, being the origin of its strong star-formation activity.

The H I distribution found in the BCDG ESO 108-G107 (Figure 2, *right*) is more than 5 times the optical size. We detected a long tail towards the NW that has peculiar kinematics and is not aligned with a faint optical tail found at the W of the BCDG. The H I distribution and kinematics of the eastern neutral gas also suggest the presence of a tail in this area.

The analysis of the H I properties of the IC 4662 is presented in van Eymeren et al. (2009). The low column density gas shows a kind of tail towards the east. The kinematics are very disturbed: the overall velocity gradient runs from the north-east with velocities of 220 km $s^{-1}$ to the south-west with velocities of 380 km $s^{-1}$, changing direction by about 90° in the centre of IC 4662. The chemical properties of some of the H II regions are also intriguing and may suggest the presence of two objects that have experienced different chemical evolution.

## 5. Conclusions

We performed a multi-wavelength analysis of some nearby BCDGs combining broad-band optical/$NIR$ and H$\alpha$ photometry, optical spectroscopy and 21-cm radio observations. We show that the H I data are fundamental to understand their nature and dynamical evolution. All analyzed BCDGs show interaction features despite if they are located in a galaxy group, a galaxy pair or are apparently isolated. Our study confirms the results provided by López-Sánchez & Esteban (2008, 2009), who concluded that interactions with or between low-luminosity dwarf galaxies are the main trigger mechanism of starbursts, specially on BCDGs. However these dwarf objects are only detected when deep optical images and complementary H I observations are obtained. Therefore, BCDGs seem not to be real isolated systems.

### References


Barnes, D.G. et al. 2001, MNRAS, 322, 486

van Eymeren, J., Koribalski, B.S, López-Sánchez, Á.R. et al. 2009, MNRAS, in prep.

Koribalski, B.S. et al. 2004, AJ, 128, 16

Koribalski, B.S. 2008, proc. of *Galaxies in the Local Volume*, Springer, p.41

Koribalski, B.S. & López-Sánchez, Á.R. 2009, MNRAS, in press

López-Sánchez, Á.R. & Esteban, C. 2008, A&A, 491, 131

López-Sánchez, Á.R. & Esteban, C. 2009, A&A, in press

López-Sánchez, Á.R., Koribalski, B. & Esteban, C. 2008a, ASSP *Galaxies in the Local Volume*, Springer, p.53

López-Sánchez, Á.R., Koribalski, B., Esteban, C. & Hibbard, J. 2008b, ASSP *Galaxies in the Local Volume*, Springer, p.301

Méndez, D.I. & Esteban, C., 2000, A&A, 359, 493