New insights into the photometric structure of Blue Compact Dwarf Galaxies from a deep Near–Infrared study

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Abstract. We present deep Near–Infrared (NIR) imaging of Blue Compact Dwarf Galaxies (BCDs), allowing for the first time to derive and systematize the NIR structural properties of their stellar low–surface brightness (LSB) host galaxies. Compared to optical data, NIR images, being less contaminated by the extended stellar and ionized gas emission from the starburst, permit to study the LSB host galaxy closer to its center. We find that radial surface brightness profiles (SBPs) of the LSB hosts show at large radii a mostly exponential intensity distribution, in agreement with previous optical studies. At small to intermediate radii, however, the NIR data reveal an inwards flattening with respect to the outer exponential slope ("type V SBPs", Binggeli & Cameron 1991) in the LSB component of more than one half of the sample BCDs. This result may constitute an important observational constraint to the dynamics and evolution of BCDs. We apply a modified exponential fitting function (Papaderos et al. 1996a) to parametrize and systematically study type V profiles in BCDs. A Sérsic law is found to be less suitable for studying the LSB component of BCDs, since it yields very uncertain solutions.

Keywords: Galaxies: Dwarf, Galaxies: Compact, Galaxies: Structure

1. Introduction:

Studies of Blue Compact Dwarf Galaxies (BCDs) are crucial for understanding the starburst–driven evolution of gas–rich low–mass extragalactic systems at low and high redshift. Particularly important for the study of BCDs is the information on their stellar low-surface brightness (LSB) host galaxy (Loose & Thuan 1986). This evolved component, present in most types of local dwarf galaxies, contains the bulk of the stellar mass of a BCD and is most probably dynamically relevant. It is therefore likely that its structure (e.g., mass density distribution) influences the global star formation process in a BCD. However, the intensity distribution of the LSB component is uncertain close to its center, where it is most required to understand the centrally concentrated star–forming (SF) activity of typical BCDs. Previous optical studies of these systems have been restricted to the LSB periphery (≥2 exponential scale lengths) where the emission of the starburst becomes negligible. At NIR wavelengths, the fractional flux contribution of the
starburst is comparatively low, allowing to study the LSB hosts of BCDs closer to their center. We present results from the first large BCD sample, comprising > 30 objects of all morphological subclasses, which was observed sufficiently deep in the NIR to systematically study the structural properties of the LSB hosts. The complete analysis of the sample is presented in Noeske et al. (2002) and Cairós et al. (2002).

2. Observations, data reduction & analysis

NIR images were observed at the Calar Alto 3.6m telescope with OMEGA PRIME, at the ESO NTT with SOFI and at the ING 4.2m WHT with the INGRID camera. Typical on-object integration times are > 20 min in $J$, > 25 min in $H$ and > 30 min in $K$. All instruments were equipped with 1k×1k pixel NIR arrays, which improve both the observing efficiency, and the quality of the background correction. The latter is essential for surface photometry studies, and could be further refined through a data reduction software package we developed, which complements standard NIR reduction techniques by new correction procedures. Surface brightness and color profiles (Fig. 1), derived as described in Papaderos et al. (2002), reach limiting surface brightnesses of 23.5 - 25.5 mag/$''$ in $J$ and 22 – 24 mag/$''$ in $H$ and $K$.

3. Results

(i) Contrast-enhanced NIR maps uncover numerous morphological details within the SF component (Fig. 1), which may hold clues to the history and spatial progression of SF activities in BCDs. In some cases, a combination of NIR and optical data indicates appreciable and non-uniform dust absorption on a spatial scale as large as ~1 kpc.

(ii) Surface brightness profiles (SBPs) of our sample BCDs can at large galactocentric radii $R^*$ be well approximated by an exponential fitting law (Fig. 1), in agreement with previous evidence from optical surface photometry. Also the exponential scale lengths $\alpha$ derived in the optical and NIR are in mutual agreement, implying minor optical–NIR color gradients within the LSB component. For the majority of the LSB host galaxies in our sample we derive optical-NIR colors indicative of an evolved stellar population of subsolar metallicity.

(iii) On a galactocentric radius of 1...3$\alpha$, the underlying LSB component of several BCDs shows a conspicuous intensity depression with respect to the purely exponential slope derived for larger radii (Fig. 1, right). Such inwards flattening exponential SBPs, classified "type V"
Figure 1. **Top:** $J$ band images and $J$ isophotes at intensity levels as indicated in the legends. The insets show contrast-enhanced blow-ups of the regions indicated by the brackets. **Center:** Surface brightness profiles in $J$, $H$, and $K$. Heavy grey lines show fits to the LSB component by exponential (Tol 3) and modified exponential (Haro 14) functions. **Bottom:** Color profiles. Thick lines to the right indicate the mean colors of the LSB host galaxy.

in Binggeli & Cameron (1991), are not uncommon in other low-mass systems, e.g. dIs. Our NIR data reveal signatures of a type V SBP in the LSB host of more than one half of the sample BCDs, suggesting a higher frequency of such profiles than previously indicated by optical studies. This discrepancy is likely attributable to the extended starburst emission in optical wavelengths, which can readily mask a flattening in the inner part of the underlying stellar LSB component.
A possible high frequency of type V profiles among dwarf galaxies is not expected to significantly change a structural dichotomy of the LSB component of BCDs from other types of dwarf galaxies (Papaderos et al. 1996b). However, it could have important implications for our view about BCDs, as it would significantly increase the estimated starburst-to-LSB luminosity fraction, and therefore the amount of photometric fading of these systems, once the starburst activity has terminated. This information is crucial for, e.g., establishing or discarding the hypothesis of faint dwarf spheroidals being the evolutionary endpoints of BCDs. In the same way, a type V intensity distribution would impose new observational constraints to the total stellar mass and its intrinsic luminosity density profile within the LSB component of BCDs.

(iv) The physical origin of type V SBPs in dwarf galaxies is to date not understood. We find that such SBPs can be well approximated by a modified exponential fitting formula (Papaderos et al. 1996a). This empirical model is found to be suitable to systematize the structural properties of BCDs, and for a meaningful decomposition of the SBPs of these systems into the LSB and the starburst component. A Sérsic law can also yield good fits to type V profiles, albeit small systematic residuals. However, the practical applicability of the Sérsic law to the LSB emission of BCDs is limited by the strong non-linear coupling of its free parameters, and the extreme sensitivity of the achieved solutions to, e.g., small uncertainties in the sky subtraction and SBP derivation.

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