Near-IR Imaging of LSB Galaxies: the High and Low HI Content Cases

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Abstract. Recently acquired near-IR imaging (J and Ks) of low surface brightness galaxies is presented. The data includes 52 galaxies with log[MHI/M⊙] ≤ 9.0 and 58 galaxies with log[MHI/M⊙] ≥ 9.5. These galaxies have been selected from the catalogue of Impey et al. (1996), and all of them are observable from both hemispheres. The principal goal of this research is to investigate the poorly understood giant and old stellar content of these galaxies. Current work includes total and isophotal photometry, and comparison with spectrophotometric models of galaxy evolution, including the role of age and metallicity. Already allocated observing time at LCO for this year will provide high S/N B and I imaging.

1. Introduction: Background and Rationale

Low surface brightness galaxies (LSBGs) have been the subject of interest since Zwicky (1957) and Disney (1976) emphasized the fact that the central surface brightnesses of disk galaxies in the Hubble sequence Sa-Sb-Sc (which fall in a rather narrow range) might be the result of a selection effect, which is due to the difficulty in discovering galaxies of very low surface brightness. In practice, LSB means galaxies whose central surface brightness is fainter than 22.0 mag arcsec⁻² in the B band, and seem to have different properties than those of brighter galaxies, which might imply a different evolutionary track.

Previous studies (Longmore et al. 1982) has shown that LSBGs are much more gas rich than high surface brightness ones, and bluer than “normal” late type galaxies (de Blok, van der Hulst & Bothun 1995; Sprayberry et al. 1995; Dalcanton, Spergel & Summers 1997). These facts combined with their low metallicity content (McGaugh 1994; de Blok & McGaugh 1997), result in a low star formation rate in an unevolved system. However, because of the low surface brightness of the underlying population, only a small fraction of the total number of stars is needed to make the colors significantly blue. Therefore, the study of the M/L ratio in the near-IR for these galaxies would lead to a clearer picture. Also, more observational constraints are needed in order to explain the blue colors and low metallicity and to disentangle the role played by age and

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metallicity. Combined near-IR and optical observations are a perfect probe to clarify these issues.

Knezek & Wroten (1994) observed a small sample of LSBGs in $J$, $H$ and $K$, but the sample was very small and biased towards massive galaxies.

The fact that the integrated colors of some LSBGs are quite red (like Malin-type objects) suggests that they contain a significant old population of stars and were therefore not formed recently. The near-IR colors are good tracers of the mass, where additionally the evolution factor is minimized by the weakly evolving dominant population of red giant stars and low mass stars. Moreover, integrated color observations by McGaugh (1992) show that only the reddest LSBGs have bulges. The super-giant galaxies Malin 1 and Malin 2 appear to be redder than the majority of LSBGs with luminosities that are comparable to those of normal spirals. Our preliminary results in the near-IR seem to agree with this picture, in the sense that more massive LSBGs (high HI mass) are redder than less massive (small HI masses), low luminosity LSBGs.

With these caveats in mind, this systematic study will provide fundamental properties of LSBGs both in the optical and in the near-IR (for example, to derive the size of these galaxies in terms of the surface brightness in both the near-IR and in the optical). This offers the possibility of tracing accurately the mass distribution using near-IR imaging, and the luminosity distribution using optical colors, helping to trace better the evolutionary tracks of these galaxies. The spread in the observed integrated optical colors of LSBGs is large, showing that such objects have had a wide range of evolutionary histories. Near-IR colors prevent the melting of the light of all the star populations to infer the evolutionary (and metallicity) path of these galaxies. Optical and near-IR colors combined give a complete picture of the spatial distribution of the young and old stellar populations, as well as allow to quantify the degree of internal absorption by dust. Moreover, recent modeling of LSBGs predict that, from the assumption that blue LSBGs are currently undergoing a period of enhanced star formation, there should exist a population of red, non-bursting, quiescent LSBGs (Gerritsen & de Blok 1999; Bell et al. 2000; Beijersbergen, de Blok, & van der Hulst 1999). These galaxies should then also be metal-poor and gas-rich, and share many of the properties of the LSBGs observed in the optical. Near-IR imaging is a valuable window to test this last hypothesis and to study the stellar content of LSBGs, allowing to compare the properties of their old stellar population with the features observed for the young populations using optical data, particularly from blue bands.

2. The Sample

In order to investigate these issues, I have selected two subsamples of LSBGs from the catalogue of Impey et al. (1996). The two subsamples differ in the HI mass of their galaxies. The first subsample contains LSBGs with $\log[M_{HI}/M_\odot] \leq 9.0$ (52 galaxies, sample A) and the second subsample galaxies with $\log[M_{HI}/M_\odot] \geq 9.5$ (58 galaxies, sample B). In the final catalogue, only galaxies with $\mu_0(B) \leq 23.5$ mag arcsec$^{-2}$ are included. This $B$ limiting central magnitude corresponds roughly to the equivalent limiting magnitude in $K$ for the IR Classic Camera at the Las Campanas 2.5m du Pont telescope for
Figure 1. Mosaic of 38 low surface brightness galaxies of sample A already reduced in the near-IR. In left panel $J$ images and in right panel $K_s$ images. Typical frame size is $\sim 1.5' \times 1.5'$. Total exposure time for each galaxy varies between 30 min and 70 min in $J$, and between 45 min and 110 min in $K_s$.

a stellar image in one hour integration time (5$\sigma$ and 1.5 arcsec aperture), given that $< B - K > \sim 2.5 - 3.0$ for LSBGs (see for example Tully & Verheijen 1997). All the galaxies already have relevant information, such as radial velocities (i.e. distance), HI content, $B_{\text{total}}$ magnitudes, and the central blue surface magnitude $\mu_0$. Also some morphological information is available (Hubble types).

3. Status of the Project and Prospects

Currently, most of the near-IR observations are completed and 90% of them are reduced. All the sample will be imaged in $B$ and $I$ during 2000. Therefore, the final catalogue will include high S/N ($\sim 10 - 15$) $B$, $I$, $J$ and $K_s$ imaging of 110 LSBGs from the catalogue of Impey et al. (1996), as described in §2. The current work with the data includes (1) structural characterization of the near-IR images (sizes, shapes and morphology), (2) computation of different kind of calibrated magnitudes for the whole sample, (3) characterization of the photometric profiles in terms of magnitudes and colors, and (4), comparison of derived photometric results with spectrophotometric models of galaxy evolution, considering the role of metallicity and dust, e.g. using PEGASE (Fioc & Rocca-Volmerange 1997) and GISSEL96 (Charlot, Worthey, & Bressan 1996). The approach will be similar to that applied by Galaz (2000) for a sample of E+A galaxies and by Bell et al. (2000). I emphasize that this is currently a unique large and homogeneous database of LSBGs with reduced near-IR imaging.

Figures 1 and 2 show $J$ and $K_s$ mosaiced images of 38 reduced LSBGs from sample A. Figures 3 and 4 mosaiced images of 47 reduced LSBGs from sample B. The core of the reduction pipeline uses a modified version of DIMSUM, and has been applied successfully to all the data (see also Galaz 2000). In the future, we
Figure 2. Similar to Fig. 1 but for **sample B**.

expect to observe fainter LSBGs in the near-IR and in the optical, using larger telescopes.

**Acknowledgments.** I acknowledge Carnegie Observatories for the huge (but necessary) telescope time allocated for this project. This work is supported under agreement between Fundación Andes and Carnegie Institution of Washington.

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