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Exploring the Sensitivity Limit: 21-cm Observations of Low Surface Brightness Galaxies with the Arecibo Telescope

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Abstract. The wide bandwidth, high sensitivity, and flat baselines of the Arecibo Gregorian telescope make it an excellent instrument to probe the HI content of LSB systems. In this paper we briefly describe a few of the results to come out of Arecibo observations of these enigmatic systems.

1. Introduction

Despite the difficulty in detecting low surface brightness (LSB) galaxies, it has been well established in recent years that these diffuse systems play a significant role in both defining the baryon content of the Universe and in our understanding of the distribution of local galaxy types. Additionally, LSB galaxies afford a unique view into star formation and evolution on galactic scales.

The wide bandwidth, high sensitivity, and flat baselines of the Arecibo Gregorian telescope make it an excellent instrument to probe the HI content of LSB systems. Obtaining our source list from a variety of (optically determined) galaxy catalogs, ranging from the UGC through new LSB catalogs based on both DPOSS and other galaxy searches, we have spent the last three years determining the HI properties of LSB systems. Our studies have greatly expanded our knowledge of these diffuse systems, and include - the detection of possibly the highest M_{HI}/L_B galaxies known; discovery of red, gas rich LSB galaxies; extending the known local galaxy surface brightness distribution function by one magnitude; and the discovery a large number of massive LSB galaxies, including a significant number of galaxies with LSB disks surrounding active galactic nuclei.

2. High M_{HI}/L_B Galaxies

LSB galaxies are often thought of as gas rich, unevolved systems. With that in mind, it is perhaps not surprising that LSB galaxies appear to be some of the most gas rich galaxies known. What may be more surprising, though, is that there is no clear correlation between the galaxies' central surface brightness and

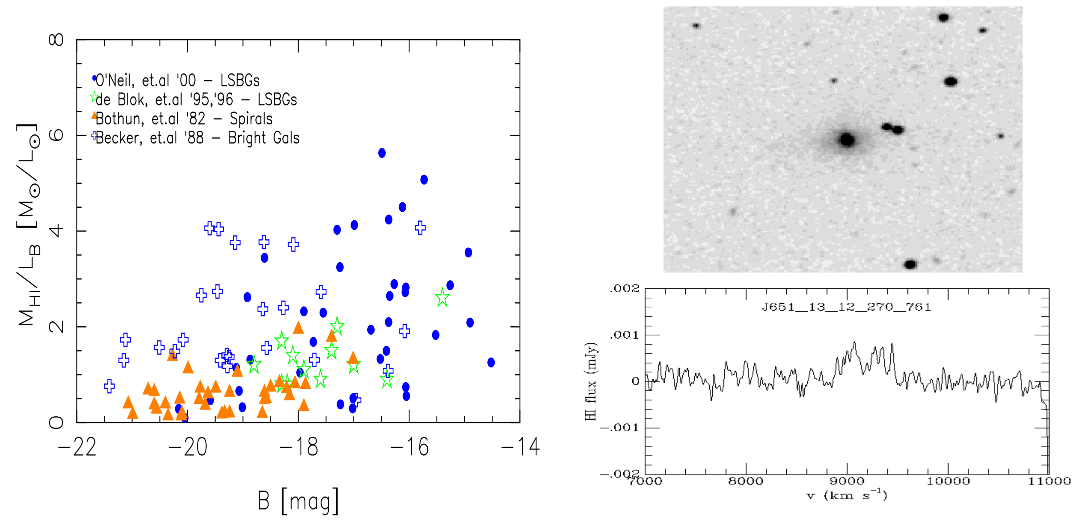

Figure 1. (a) Absolute B magnitude versus HI Mass-to-Luminosity ratio for a variety of both LSB and HSB Galaxies (from O'Neil, Bothun, & Schombert 2000). (b) DPOSS and HI profile of a 'typical' LSB AGN galaxy.

their M_{HI}/L_B ratio. Additionally, no correlation is seen between the galaxies' gas mass ratio and their colors, with the surveys discovering a number of fairly gas rich LSB galaxies with $(B-V) > 1.0$. This supports the idea of LSB galaxies having a low overall star formation rate, punctuated by localized bursts of star formation.

3. LSB AGN Galaxies

A preliminary search was undertaken last winter using eight plates from DPOSS (the Digital Palomar Sky Survey) that contain some fraction of 2MASS coverage (about 3 deg^2). Forty candidates were produced, of which ten were searched with the Arecibo Gregorian system. Eight of the ten candidates were detected at 21-cm, one of which is shown in Figure 1b. All detected galaxies have the characteristic AGN nucleus surrounded by an LSB disk. All eight also have HI widths in excess of 350 km s^{-1}. Assuming these galaxies follow the baryonic Tully-Fisher relation (McGaugh, et.al 2000), their masses will exceed 10^{12} M$_\odot$.

4. Local Galaxy Surface Brightness Distribution

To obtain a surface brightness distribution through $\mu_B(0)$=25.0 mag/arcsec^2, a bi-variate volume correction was applied to the data in the O'Neil, Bothun, & Schombert (2000) catalog of LSB galaxies, velocities, etc. This extension by one magnitude of the surface brightness distribution function still shows a flat (slope=0) function from the Freeman value of $\mu_B(0)$=21.65 mag/arcsec^2 through the survey limits at $\mu_B(0)$=25.0 mag/arcsec^2. This indicates that a significant

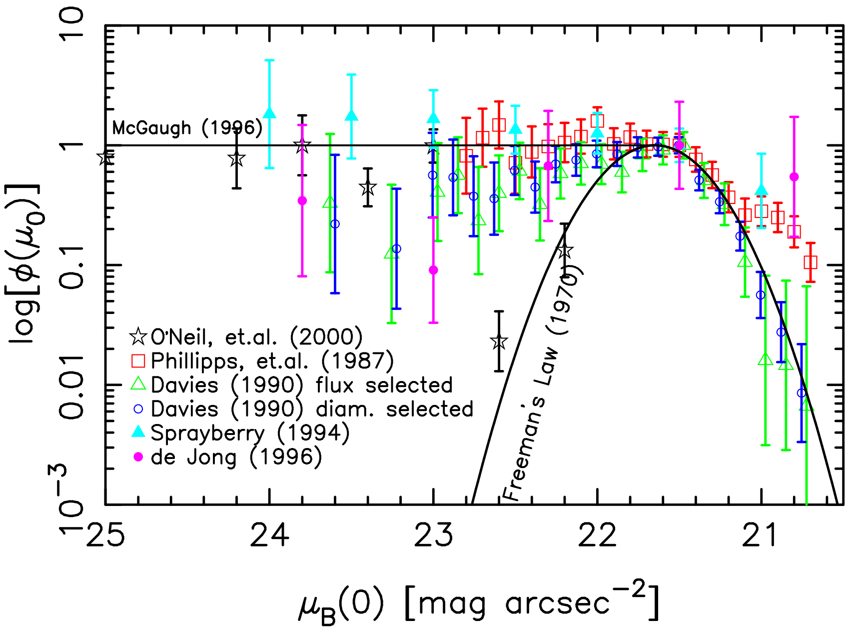

Figure 2. The volume corrected surface brightness distribution as given in O'Neil & Bothun (2001).

percentage of the galaxy number density, and possibly the baryonic density, of the local Universe lies in LSB galaxies.

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