Observations of new galaxies in the Zone of Avoidance using the Arecibo Radio Telescope

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Abstract: As part of an undergraduate research techniques course, we detected the neutral hydrogen (HI) spectrum of the galaxy SPITZER192404+145632. This galaxy is located in the Zone of Avoidance (ZoA), a region of the large-scale distribution of galaxies that is obscured by our own galactic disk. Using the Arecibo Observatory*, we were able to confirm the infrared detection made by Marleau et al. (2008). We find a redshift of $z = 0.019$, an HI mass of $M_{HI} = 1.02 \times 10^9 M_o$, and dynamical mass of $M_T \approx 3.9 \times 10^{11} M_o$.

Motivation: The Zone of avoidance (ZoA) is located in the night sky in the direction of our galactic disk. Observations of galaxies at optical wavelengths are extremely difficult in this region because of absorption of light by the dust in the disk of the Milky Way. Therefore, fewer objects have been found in the ZoA than in other regions of space (see Figure 1). Observations in the ZoA with very sensitive infrared and radio telescopes, present an opportunity for astronomers to discover new galaxies, as waves at these wavelengths are not absorbed by dust. By filling in the gaps of the ZoA, we can better understand the large-scale structure of the universe.

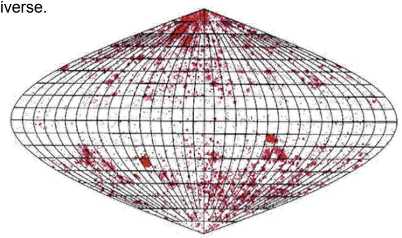

Figure 1: The Zone of Avoidance. This is a panoramic view of the large scale distribution of galaxies around the Milky Way. Note the bare region along the equator of the image.

Previous Work: The Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) is a survey carried out by a UW team of astronomers using the Spitzer Space Telescope. By looking in the infrared, the telescope is able to see through most of the dust that obscures our view in the ZoA. A recent paper by Marleau et al. listed 25 possible galaxy (Figure 2) detections in the ZoA from GLIMPSE data. With their paper as a guide, we used the Arecibo radio telescope to perform follow-up observations of one of their possible galaxies: SPITZER192404+145632.

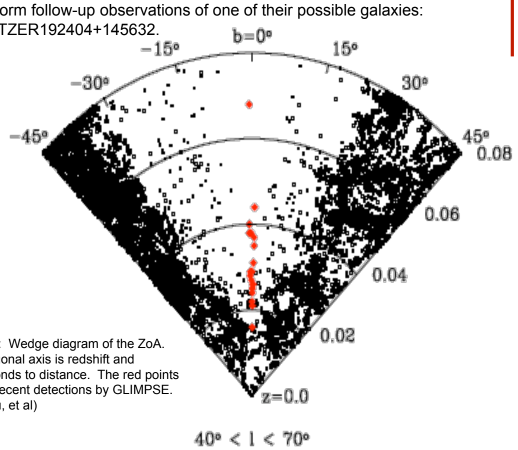

Figure 2: Wedge diagram of the ZoA. The diagonal axis is redshift and corresponds to distance. The red points are the recent detections by GLIMPSE. (Marleau, et al)

Observations: We observed remotely on October 16, 2008, using position switching (ON/OFF) observations with the L-wide receiver of the Arecibo Observatory. We simultaneously observed the emission line of atomic hydrogen at a frequency of 1420 MHz, and three emission lines of the OH molecule (1665, 1666, and 1720 MHz). We calibrated spectra into temperature units using a source of known temperature (noise diode). After reduction, the spectrum showed an approximately three sigma detection of the galaxy in HI.

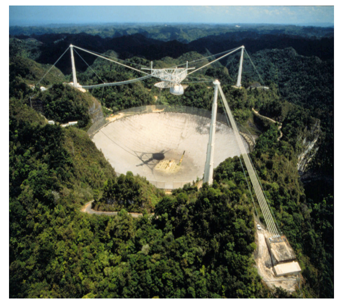

Figure 3: The Arecibo Observatory is located in Puerto Rico, and is over 300 meters in diameter.

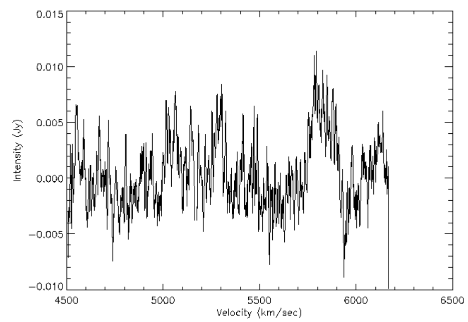

Figure 4: Spectrum of the galaxy SPITZER192404+145632. The object is located at the spike in intensity at 5800 km s^{-1}.

Conclusions and future: Our work provides the first HI detection of the galaxy SPITZER192404+145632. Furthermore, we were able to estimate fundamental properties of this galaxy and provide insight into its structure. Our results are an important step in understanding physical properties of galaxies in the ZoA, which are often hidden from our view. We plan to travel to Puerto Rico in the summer of 2009 to confirm our results with a 10-sigma detection after 1-2 hours of integration time.

Analysis: Using the observed spectrum, we calculate the systemic velocity, distance, rotational velocity, HI mass, and dynamical mass of SPITZER192404+145632. The systemic velocity is found by simply evaluating the midpoint velocity of the spectrum. We found $v_{sys} = 5800$ *km/s*. This corresponds to a redshift of $z = 0.019$. The distance to the galaxy is determined using Hubble's Law:

$$v_{sys} = H_0 D$$

Where H_0 is Hubble's constant, taken to be 75 km/s/Mpc, and D is the distance to the galaxy. We arrive at

$$D = 77.6Mpc$$

The HI mass of the galaxy is determined by integrating the spectrum, and using the relation:

$$M_{HI} = 2.36 \times 10^5 \times D^2 \times \int F(v)dv = 1.02 \times 10^9 M_o$$

Where M_{HI} is in solar masses, D is in Mpc, F is in Jy, and v is in km/s. Finally, we estimate the dynamical mass of the galaxy. To do this, we use the relation:

$$M_T = 2.33 \times 10^5 \times v_{rot}^2 \times R$$

where M_T is in solar masses, v_{rot} is the rotational velocity in km/s, and R is the radius of the galaxy in kpc. The rotational velocity is read off of the spectrum as HWHM: v_{rot}=*76.5 km/s*. The radius is approximated using Figure 1 in Marleau et al.: *R ~ 28 kpc*. Using this result, we arrive at $M_T = 3.9 \times 10^{11} M_o$.

Comparison: To confirm our methods, we also observed a well known spiral galaxy, UGC11362. The observed spectrum is shown below. Using the same methods, we arrived at the results in Table 1.These results match very well with the known properties of UGC11362 given by O'Neil, et al. Therefore, we have confidence in our methods and calculations.

$v_{sys} = 4204.7 km/s$
$D = 56.06 Mpc$
$M_{HI} = 3.33 \times 10^9 M_o$
$v_{rot} = 96.5 km/s$
$M_T = 1.77 \times 10^{10} M_o$

Table 1. Results from observation of UGC11362.

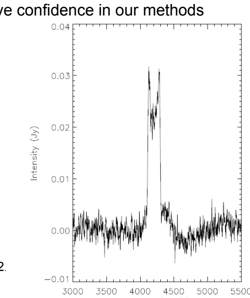

Figure 5: Spectrum of the galaxy UGC11362

References:
Marleau F.R. et al. 2008, ApJ, 136, 662
O'Neil, K. 2004, ApJ, 128, 2080

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