Andromeda Galaxy as Seen by Small Radio Telescope

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Abstract

The Andromeda Galaxy is very bright at the wavelength of neutral hydrogen (HI), 21 cm. However, Andromeda is a point source for a small radio telescope (SRT) with a 7˚ half-power beam width, making it appear dim. More than 200 SRTs exist throughout the USA, yet no SRT has detected Andromeda. During the summer of 2013 we used the UW's SRT in Pine Bluff in an experiment to detect Andromeda. Significant work was dedicated to calibrating the SRT's intensity (temperature) scale, as well as the overall filter response prior to analyzing Andromeda observations. We have a marginal detection centered near -525 km/s, right where the HI signal Andromeda's signal is expected to be the brightest. This is likely the first SRT HI detection of Andromeda. Our observational technique can be applied to detect other dim objects using similar SRT's.

Scientific Motivation

Figure 1. Andromeda in visible light
(Schoening, Harvey and NOAO)

Can SRT's view dim objects?

The Andromeda Galaxy is one of the nearest galaxies to the Milky Way, and contains large amounts of neutral hydrogen (HI), which is the basic material that ends up in stars and also clearly traces the overall structure and kinematics of galaxies. Therefore, it can be easily studied to understand our and other galaxies. However, Andromeda is a point source for a 2.3m parabolic reflector SRT with 7° half-power beam width, which dims Andromeda's signals to near the noise level, making it difficult to detect. We attempt to find a method to detect Andromeda using only a 2.3m SRT and standard data processing software.

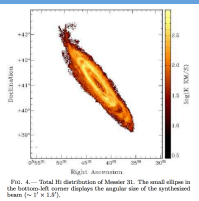

Figure 2. Andromeda in radio light
(Chemin, Carignan and Foster, 2009)

Methods

Calibrate Telescope:
Observe portion of Milky Way with known HI emission to calibrate telescope's calibration diode

Observing:
Record Andromeda for six hours/night, for six nights

Correct Velocity:
Change velocity from topocentric radial velocity (velocity to/from Madison) to LSR velocity using IDL subroutines from NASA

Calculate Bandpass Shape (a.k.a. gain function):
Tested modifications of the Heiles' (2011) method and polynomial fitting to calculate gain from SRT's base-band filter, using the portion of spectrum where LSR velocity ≤-550 km/s and ≥-500 km/s (outside of main peak)

Create Spectrum:
Correct raw spectra for gain and; average to form a single spectrum (Figure 3)

Results

Andromeda Spectra

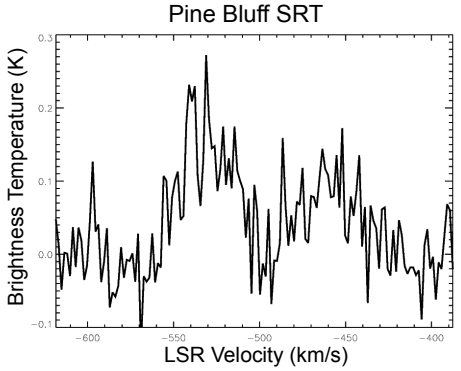

Figure 3. Approx. 70 minutes integration; averaged and corrected for telescope gain. We detect a peak centered at -525 km/sec where Andromeda is expected to be the brightest.

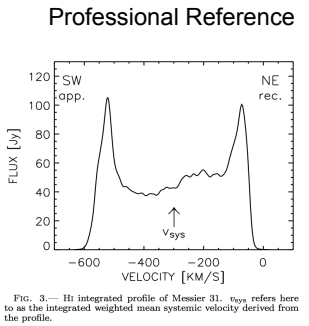

FIG. 3.— HI integrated profile of Messier 31. v_{sys} refers here to as the integrated weighted mean systemic velocity derived from the profile.

Figure 4. Spectrum of Andromeda's HI showing the -525 km/s peak at ~105Jy
(Chemin, Carignan and Foster, 2009)

Discussion and Conclusion

Based on Chemin et al. observations we expect the peak intensity centered at -525 km/s of only 0.096K when observed with the SRT. This is very close to the signal we detect. In addition, after trying several different methods for gain correction we always see peak at -525 km/s. This gives us confidence that the detected feature is real but still only ~3 times higher than the noise floor. We are confident that we have detected Andromeda, but future work is needed to confirm this detection.

Future research will focus on creating a general model of the SRT's gain function at varying input frequencies and adding more integration time to improve the detection. Understanding the sources of radio interference at Pine Bluff will also be important as many of our spectra were contaminated by non-astronomical signals.

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