LATEST RESULTS OF THE SETHI SURVEY AT ARECIBO

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Abstract SETHI is a survey of the distribution of galactic neutral hydrogen being performed comensally at the NAIC Arecibo Observatory. At the same time that observers use receivers in the Gregorian dome, SETHI is recording a 2.5MHz band centered at 1420 MHz from a flat feed on Carriage House 1. During normal astronomical observations, the SETHI feed scans across the sky at twice the sidereal rate. During 4 years of observations, we have accumulated over 15,000 hours of data covering most of the sky accessible to Arecibo. This survey has higher angular resolution than existing single dish surveys and higher sensitivity than existing or planned interferometric surveys.

These data are being converted into spectra and is housed in a database at UCB. It is our intention to make this data publicly accessible. We briefly discuss the status of this effort and show some results obtained with this data.

Keywords: Interstellar Medium, Surveys

1. Survey Description

The UCB SETI searches use an uncooled receiver on the 1420 MHz flat feed on Carriage House 1 at the National Astronomy and Ionospheric Center's 305 meter radio telescope in Arecibo, Puerto Rico. This carriage house is opposite the zenith to the primary receivers in the Gregorian dome. This unique arrangement allows observations to be conducted without interference with other uses of the telescope. This results in two main modes of observation. If the primary observers feed is stationary or stowed the beam scans across the sky at the sidereal rate. If the primary observer's feed is tracking a position on the sky, the beam scans the sky at twice the sidereal rate. At twice the sidereal rate, the 0.1° beam width corresponds to a 12 second beam transit time. After several years, the bulk of the sky visible to the Arecibo telescope is covered. (Korpela et al. 2001)

The time domain data for the sky survey is recorded as follows: first, a 30 MHz band from the receiver is converted to baseband using a pair of mixers and low pass filters. The resulting complex signal is digitized and then filtered to 2.5MHz using a pair of 192 tap FIR filters in the SERENDIP IV instrument. (Werthimer et al. 1997) One bit samples are recorded on 35 GByte DLT tapes (one bit real and one bit imaginary per complex sample). These tapes are shipped to Berkeley for use in the SETI@home program.

The SETHI program analyzes these tapes to extract hydrogen spectra. The 2.5 MHz time series data are converted to raw spectra using 2048 point FFTs ($\Delta\nu$=1220 Hz). 6144 FFTs are accumulated into a single power spectrum of 5.033 second integration time. The resulting power spectrum is corrected for 1 bit sampling effects by using the Van Vleck correction. The spectrum, its start and and end coordinates, and the observation time are stored in a database for future use.

Because no absolute power calibration is available in the receiver or recorder subsystem we must calibrate our observations using existing surveys. We perform this calibration by performing a linear fit of the SETHI spectra to spectra from the Leiden-Dwingeloo survey (LDS). While this method has the drawback of reducing our sensitivity to changes on total HIcolumn density on scales smaller than the LDS beam size (0.5°), changes in the spectral velocity profile are well preserved on scales near the beam size.

The spectral fitting results in an estimate of the system temperature (including any background continuum components). Our system temperatures lie between 60 and 170 K approximately 65% of the time. Excursions outside of this range due to receiver problems or excessive noise environments result in unusable data.

2. Analysis procedure

At this point, we have looked in detail at only a small fraction of the data in the SETHI database. We have developed initial analysis code in IDL. Spectra are selected from the SQL database based upon coordinates. The calculated system temperature, and the residuals of the fit to the LDS spectrum, are used to reject unusable data.

Because of the mode of survey operation which results in 5 second sweeps of varying direction and length, mapping the spectra into sky coordinates is somewhat complicated. For each spectrum we define a spatial weighting function that is a Gaussian approximating the beam profile, convolved with the path of the telescope beam over the course of the observation. The weighting function is area normalized to a value of 5.033 seconds. An additional weighting factor of the one over the RMS residuals of the LDS fit is then applied.

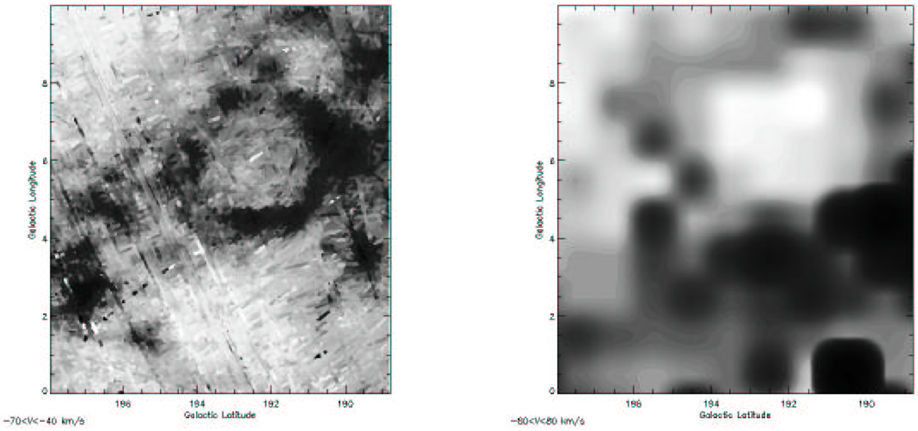

Figure 1. a) A SETHI velocity slice of a region near the galactic plane showing a shell like structure. b) A WHAM Haffner et al. 2003 Hα image of the same region indicating low surface brightness within the shell structure.

A spectral data cube is generated by summing the spectra multiplied by their weighting function at each spatial pixel in the cube and normalizing by the sum of the weighting function.

Figure 1 shows a velocity slice integrated from -70 to -40 km/s of an area close the galactic plane near the anti-center direction. Note the presence of artifacts due to the observation method. The diagonal features in the left side of the image are lines of constant declination near 18° declination. The feed spends much of its time parked at these positions. Because of the large amount of observing time at these points, the image is more likely to be contaminated with unremoved RFI or high system temperature data. We are working to improve our data selection process to reduce such artifacts.

We note the presence in this image of what appears to be a series of interlocking shells, with the largest being centered at $(l,b) = (192,6)$. A search in other wave bands indicates that the shells may be limb brightened in Hα and have a low surface brightness interior to the shell. The ROSAT $\frac{1}{4}$ keV band survey images indicate that the X-ray surface brightness is also low interior to the shell. This may indicate that the shells are somewhat old supernova remnants in which the interior gas has cooled below 10^6 K. We are proposing to make more detailed Hα maps of this region to investigate further.

3. Summary

The SETHI survey has processed about 15,000 hours of observations made at the Arecibo radio telescope to produce 11 million HIspectra. Survey data are still being collected, and data processing continues. We plan to make these data and the processing tools we use available via the World Wide Web in early 2004. We are working to improve our RFI and low-quality data rejection methods and to improve the methods by which generate data cubes for analysis.

Acknowledgments

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