

**The SPS Milky Way Map:
Radio Observations of the Milky Way Galaxy at 1420 MHz**

SPS Undergraduate Research Award – “Final” Report, December 14, 2010

In late fall of 2009, we took possession of a slightly damaged, surplus C-band TV antenna, donated to us by Utah Public Radio, to use as a radio telescope. In December 2009, we received an SPS Undergraduate Research Award totaling \$2,000 (for which we are very grateful) to help instrument the telescope. Twelve SPS students have worked on the project to date.

Developments to date include:

- * Dish refurbishment was completed.
- * Designs were drawn for mounts to enable pointing the dish along the meridian for drift scan operations.
- * A mini Radio Astronomy Workshop led by Dale Hooper (USU-SDL), a local amateur radio astronomer with a backyard setup using a refurbished C-band antenna similar to ours, was held.
- * Led by Thomas Martin, the SPS research team made a poster presentation about the project at the Zone 15 meeting in Pocatello on April 9-10, 2010.
- * A SpectraCyber 1420 MHz Hydrogen Line Spectrometer from Radio Astronomy Supplies in Texas was ordered and finally received after a long wait (the instruments are special ordered and assembled individually) in early fall.
- * After receipt of our spectrometer, preliminary calibration data were acquired and analyzed at our initial location site (the roof of the Science-Engineering Research building in mid-campus). Unfortunately, we discovered that several radio sources compromised collection of high quality data at that site.
- * The search for a new, acceptable site involved numerous fits-and-starts and a considerable amount of political wrangling, the details of which are of no importance—except that only within the last month has a final site been identified and approved. The new site is adjacent to old optical observatory (near campus), the building for which provides a secure venue for our electronics and our controller computer.
- * Disassembly and reassembly of the dish has been completed with all new mounts having to be built.
- * Cabling has been run and a controller computer has been installed.

* After the winter break new calibration data will be acquired. Though not exactly the schedule we had originally planned, we are confident we will shortly be able to observe radio signals from the Milky Way and send SPS our promised map.

Budget:

Expenditures

Radio Astronomy Supplies SpectraCyber 1420 MHz Hydrogen Line Spectrometer	\$2520
Mechanical hardware for mounts	\$1000
Total expenditures to date	\$3520

Revenues

Grant from SPS	\$2000
Grant from USU Space Dynamics Laboratory	\$1000
Gift from private donor	\$525
Total revenues to date	\$3520

Student poster:

**The SPS Milky Way Map:
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Thomas Martin, Scott Jensen, Robert Call and the SPS chapter
David Peak, Faculty Mentor
Shane Larson, Faculty Mentor

Abstract

The Utah State University SPS chapter has acquired a surplus C-band TV antenna from Utah Public Radio that it will refurbish and employ as a radio telescope. The first project will be to map the neutral hydrogen radio emission from the Milky Way galaxy. The telescope will provide continuing undergraduate research opportunities for years to come.

Background

Sigma Pi Sigma Undergraduate Research Award

- Awarded January 2010
- Amount: \$2,000
- Money goes for SpectraCyber Receiver from Radio Astronomy Supplies

Hydrogen vs. Visible

- Different kinds of light are produced by different astrophysical processes.
- Observations made at 1420 MHz which is in the strong radio-emission emission line of neutral hydrogen
- Light emitted from neutral hydrogen provides different information than what is afforded by the stars

Map of Milky Way

- Use the SPS outreach
- SPS website
- Experiment for future experiments

Other Possibilities

- Measure the galaxy's rotation
- Detect radio storms on Jupiter and the Sun

Procedure

Two distinct phases for developing this

- Instrument development and characterization
- Mapping activities.

Dish:

- Utah Public Radio Acquired a 7 meter C-band TV antenna

Mount:

- Original mount will be modified to make measurements at specific declinations

Receiver:

- Purchased 1420 MHz SpectraCyber from Radio Astronomy Supplies

Other Material:

- Feed horn, low noise amplifier, software, and chokes

The antenna will be located on top of the Science Engineering Research building at USU to reduce noise from nearby sources.

Methods

Milky Way Mapping

Dish Mode:

- Point the telescope at a particular angle/declination
- As the Earth rotates, collect data
- Move to new angle, repeat
- Repeat each angle several times, to average out the noise

Determining the number of passes

- Dependent on how much sky (beam area) can be seen by the radio telescope
- Calculate the beam size using the Rayleigh diffraction limit
- $\lambda = 0.212131 \text{ m}$
- λ is the wavelength
- D is the diameter of dish

Calculations

- Frequency of Neutral Hydrogen: $f = 1420 \text{ MHz}$, wavelength $\lambda = 0.21 \text{ m}$
- $\theta = 2\lambda / D$, so $\theta = 0.002$
- Circle's Arc Length: view $\theta = 0.002$ is $\lambda = 0.21 \text{ m}$
- Need 20 passes at 1° intervals

Analyzing Data (Raw Data vs. Analyzed)

- The green spectrum plot shows what our raw data will look like for a single pass
- Take a lot of the horizontal passes, and plot the amplitude in the chart as brightness
- Assemble many passes into the Milky Way map to get the following results.