Partial 1420 MHz HI Survey of the North Polar Spur

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Submitted 2014 May ??

Abstract

We observe the north polar spur and stuff

1 Introduction

background on NPS

2 Observations

2.1 Leuschner radio dish

We use the Leuschner radio dish ($37°55'10.2''$ N, $-122°09'12.4''$ E), operated by UC Berkeley as part of Leuschner Observatory, to collect single-dish observations of the hyperfine HI line. The Leuschner radio dish, hereafter Leuschner (Figure 1), has diameter 3.6 m or 4.5 m depending on who is asked; the beamwidth is $\sim 4°$ at its operating frequency of 1420 MHz. Leuschner's view at low altitudes is blocked by surrounding hills; to the north Leuschner may point above $\sim 50°$, to the south Leuschner may point to 20–30° altitude. The Leuschner radio dish was built for the SETI Rapid Prototype Array (an early prototype for the now-underfunded and incomplete Allen Telescope Array); the dish has since been appropriated for undergraduate education.

RF waves incident on Leuschner are passed through a 200 MHz bandpass filter centered on 1420 MHz and mixed with a local oscillator (LO) signal of frequency f_{LO}; both operations are performed at the antenna feed. The LO mixing sends frequencies of interest near 1420 MHz to $\sim$ 150 MHz; this down-converted signal is routed to Leuschner Observatory facilities and bandpass filtered at 145–155 MHz.

The signal is digitized by an FPGA-based spectrometer using a polyphase filter bank; the effective sampling rate is 24 MHz giving a bandwidth 144–156 MHz; the signal of interest appears in our frequency output via Nyquist aliasing [Siemion, 2012]. To characterize system temperature and frequency-dependent gain during data reduction, we collect observations at two LO frequencies $f_{\mathrm{LO}} = 1268.9$ MHz and $f_{\mathrm{LO}} = 1271.9$ MHz. The bandwidth 144–156 MHz thus corresponds to the radio frequency bands 1412.9–1424.9 MHz and 1415.9–1427.9 MHz respectively.

2.2 Observing campaign

We observed the region of the sky with galactic latitude $b \geq 0°$ and galactic longitudes between $l = 210°$ and $l = 20°$, which contains the North Polar Spur.over the timespan of 2014 April 26 to 2014 May 5.

Unfortunately, blah was not visible from the interferometer during our observing campaign and could not be mapped.

Blah was not visible from the dish and was not mapped.

Figure 1. The Leuschner dish has beamwidth $\sim 4^\circ$ at 1420 MHz. Here the dish is shown with its erstwhile caretaker, *kartp* (courtesy of I. Domagalski, E. Herrera, K. Moses).

In order to completely map the sky, the region of interest should be sampled with spacing 2° (for beamwidth 4°). In reality, hah. We sampled most of the available region at 4° spacing

3 Data reduction

3.1 RFI removal

3.2 Calibration

3.3 Image generation

I'm afraid to admit that, due to a shortage of time, I did not write my own velocity computation etc... scripts. I was able to start on it, but did not work on baseline fitting and removal and peak identification. Working on it now would require branching Isaac's pipeline, and risk messing up the current pipeline. So I shan't do that, FOR NOW.

Later on, I would really want to be able to decompose the various peaks. It looks like our spur observations don't have multiple peaks anyways, so it's not so bad since we dgaf about the galactic plane.

4 Results

To dos...

(manual Mollweide projection + colorbars + zooming + better plots is partway done...)

completely overhaul images (manually compute mollweide projection and image interpolation instead of relying on meshgrid) include colorbars determine physiologically sensible colormaps determine best nonlinear colormapping reduce pdf file sizes...

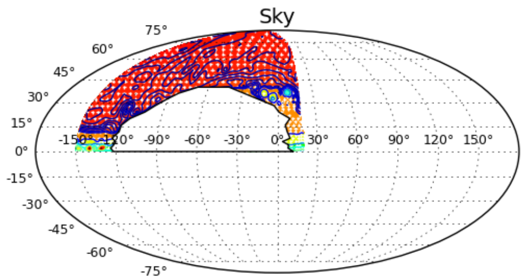

Figure 2. Column density

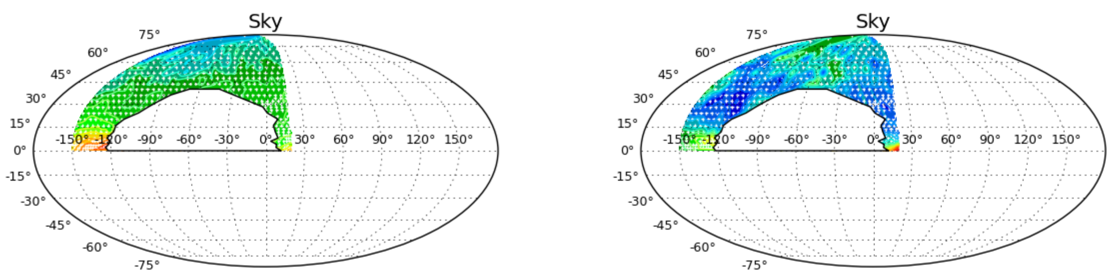

Figure 3. Mean velocity (left), stdev of velocity (right)

4.1 Blah

5 Discussion

6 Conclusions

7 Acknowledgments

Kartp noster, qui es in radiolab:
sanctificetur nomen tuum;
adveniat regnum tuum;
fiat voluntas tua.
sicut in academia, et in universitas.
Observationem nostrum cotidianum da nobis hodie;
et dimitte nobis errores nostra,
sicut et nos dimittimus erroribus nostris;
et ne nos inducas in tentationem;
sed libera nos a circumsonum.

Figure 4. (image courtesy of I. Domagalski, E. Herrera, K. Moses)

8 Author contributions

I. A. D. did stuff. C. L. did stuff. A. T. did stuff.

9 Electronic supplement

All supporting files are stored on the repository:
https://github.com/aarontran/ay121/lab4/.

10 References

Condon, J. J. and S. M. Ransom (2006), Essential Radio Astronomy, http://www.cv.nrao.edu/course/astr534/ERA.shtml.

Green, R. M. (1985), *Spherical astronomy*, 520pp., Cambridge Univ. Press, Cambridge.

Siemion, A. (2012), Leuschner Spectrometer, CASPER documentation wiki, https://casper.berkeley.edu/wiki/Leuschner_Spectrometer.

Wolleben, M. (2007), A New Model for the Loop I (North Polar Spur) Region, *Astrophys. J.*, *664*, 349–356, doi:10.1086/518711.