Partial 1420 MHz HI Survey of the North Polar Spur

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Abstract

We observe the north polar spur and stuff

1 Introduction

background on NPS. Supernovae, snowploughs, shocks, Sedov, whatever. ISM, physical properties inferrable.

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 ~ 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.

Figure 1. The Leuschner dish has beamwidth $\sim 4°$ 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.

BRIEFLY explain observing procedure, zig-zagging in lat/lon, criterion for point visibility as computed by Isaac (Check this yourself if there's time).

936 not visible?
1119 need data
444 we have data total: 2500

3 Data reduction

3.1 RFI removal

Caleb's thing. Remove spikes by taking min of 4 point bins.

3.2 Calibration

cf carl heiles' intensity handout cool method.

Integration times were chosen so error would be nice (mainly for noise). Integration time for main observations dictated by physical brightness temp.

3.3 Image generation

Due to a shortage of time, I did not finish my own velocity computation etc... scripts. Mainly needed baseline fitting/removal, peak identification. (but, after baseline removal, I'd be able to get the main science done). Working on it now would require branching Isaac's pipeline, and risk messing up the current data processing pipeline. So I shan't do that yet...

Later on, I 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 don't care about the galactic plane.

4 Results

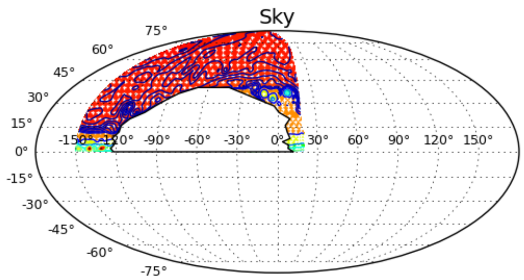

Figure 2. Column density

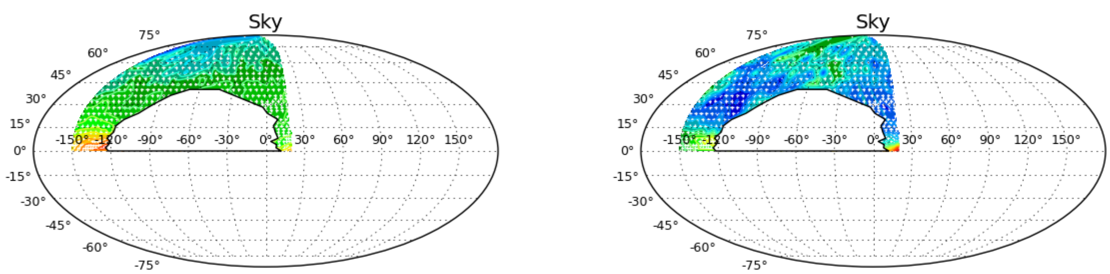

Figure 3. Mean velocity (left), stdev of velocity (right)

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...

Here's a picture of work in progress.

Comparing the dispersion to the velocity mean looks promising! As we might expect, dispersion is stronger towards the center of our postulated/expected bubble, a more robust velocity signal is seen at edges.

The column density plot absolutely needs a logarithmic color scaling to see anything outside of the galactic plane.

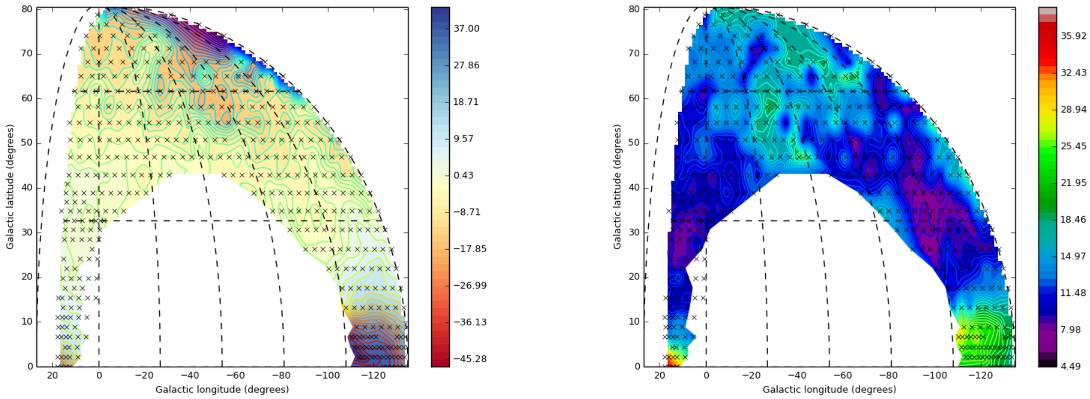

Figure 4. Mean velocity (left), stdev of velocity (right). Units are km/s for colors.

5 Discussion

IF I separate out lines and get individual linewidths etc (by gaussian fit, dispersion for indiv peaks, however you like) – start considering physical phenomena that give rise to broadening.

6 Conclusions

7 Acknowledgments

Figure 5. (image courtesy of I. Domagalski, E. Herrera, K. Moses)

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.

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

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