Lab 2

Lukas Finkbeiner

March 5, 2020

Abstract

We investigated the hyperfine hydrogen transition by calibrating our measurements to thermal noise and by averaging over many blocks of data taken in optimal time windows of the day. We investigated the speed of light using waveguides (How do they work?). Our Chi-Squared analysis is completely deficient because our data were taken too broadly to show noticeable inconsistencies.

This is a great place to have a to-do section, because I prefer to write abstracts at the end of the writing process.

* Ask Professor about the permissions thing (page 3), to make sure there are no technical difficulties.

Figure out how to make the section headers smaller. They are taking up far too much space.

1 Introduction and Background

Block diagram of the telescope electronics. Fortunately, it seems like the professor took care of most of this for you in lecture, February 11.

Gain calculation:

$$G = \frac{T_{\text{sys, cal}} - T_{\text{sys, cold}}}{\sum(s_{\text{cal}} - s_{\text{cold}})} \sum s_{\text{cold}} \tag{1}$$

Line shape:

$$s_{\text{line}} = \frac{s_{\text{on}}}{s_{\text{off}}} \tag{2}$$

Putting it all together:

$$T_{\text{line}} = s_{line} \times G \tag{3}$$

Waveguide part 1:

$$x_m = A + m\frac{\lambda_{\text{sl}}}{2} \tag{4}$$

X-band waveguide (this one requires more motivation):

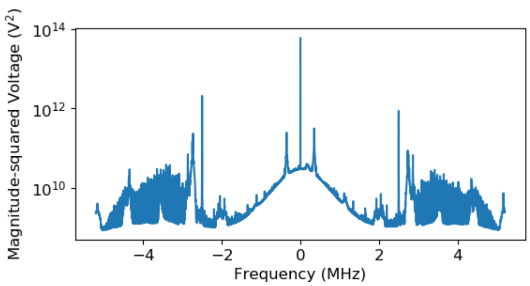

Figure 1: A semi-log plot over the range of frequencies sampled. We assume that our 2 MHz low-pass filter works, so we will dismiss the signals farther than 2 MHz from the center. Additionally, the large central spike and smaller 'bunny ear' spikes ($\pm.5$ MHz) appear on all data sets as persistent interference; we partially ignore these by limiting the y-axis. Maybe you should use an initial test sample, to discuss this.

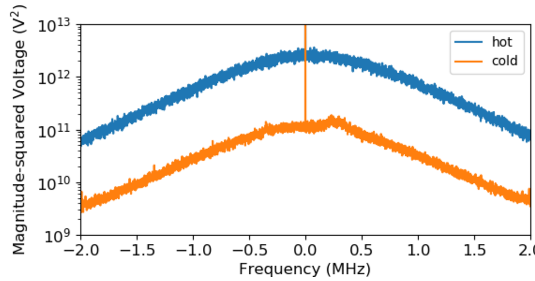

Figure 2: The 'hot' data correspond to three humans standing in front of the collector. The 'cold' data correspond to the collector pointing up at the cold sky. The noise is not an issue because of its regularity: observe the even discrepancy between the curves over the domain of interest.

$$\lambda_g = \frac{\lambda_{\rm fs}}{[1-(\frac{\lambda_{\rm fs}}{2a})]^{1/2}} \tag{5}$$

2 Methods

To place our test signal in the upper and lower sidebands, we use these two frequencies. To put the hydgrogen in the upper and lower sidebands, we set the first local oscillator to these other two frequencies.

3 Observations

As a preface, I may want to include commentary on how I had to manually alter the data, based on readings from the oscilloscope, in order to account for the imbalance in picoscope inputs?? I think not!

Figure 1 shows a host of interfering signals, a consequence of the imperfections in our setup (such as low signal-to-noise ratio from low power on the local oscillators). How can I justify ignoring the 2 MHz spikes? Aren't those bad?

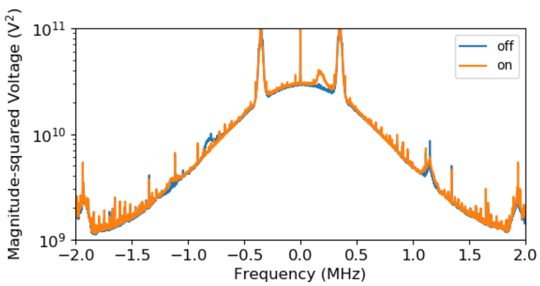

Figure 3: Combined plot of the 'on' and 'off' (LO1 at 1230 and 1231 MHz, respectively) power spectra. As we expect, the HI signal shifts by about 1 MHz between the two plots. This also supports our interpretation of the other patterns as interference: these patterns do not move between spectra.

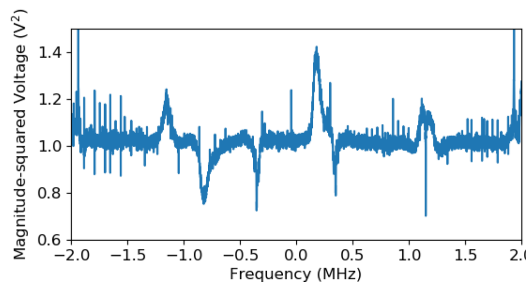

Figure 4: This one is not helpful. Replace it with the final, calibrated spectrum, thermal power units.

4 Analysis

5 Conclusions

6 Acknowledgments

You have to remedy your complete ignorance of BibTex