# Lab 3: Radio Interferometry at X Band

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**Abstract**

The purpose of this lab is to use the interferometer (signals from two telescopes on the roof multiplied) to obtain data for the Sun, the Moon, and an object of our choice. Our group chose the object Cassiopeia A (Cas A). After observing, the next main goal of the lab was to use least square fitting to derive angular diameters for the Sun and the Moon and derive the declination for Cas A.

## Introduction

The object our group decided to observe was Cas A. Cas A is a supernova remnant in the constellation Cassiopeia. The given RA and DEC for Cas A was from 2000. The RA was 23hr 23min 24sec and the declination was 40° 44' 2.10". We use the 12GHz interferometer to get the data for Cas A and for the Sun and the Moon as well. The interferometer multiplies the signals from each telescope on the roof and measures the time average.

### First Observation: Cas A

Before observing Cas A, we first made a quick observation of the sun in order to make sure everything was working properly. We could see from the power spectrum of the quick sun observation that we were ok to begin observing Cas A. In order to see when Cas A was going to be visible in the sky, I made a program which first used IDL's PRECESS function which corrected the RA and DEC which was given for the year 2000 for our year, 2017, then used rotation matrices to convert from the new RA and DEC values to HA and DEC and then to altitude and azimuth. The program gave values of altitude and azimuth values for every hour of the day. If we were given a negative value for the altitude, then we would know the object was below the horizon. However, all the values given for altitude were positive values. This meant that Cas A will always be above the horizon for our latitude, 37.87°. This makes sense because objects in the sky will appear to make a circle around the north star (which is, at our latitude, 37.87° above the horizon) so any object that appears close enough in the sky to the north star will appear to circle around the north star without ever going below the horizon). Cas A is one of these objects, so we were lucky enough to be able to observe at any time of the day. We ended up observing for a full 24 hours.
After looking at the data, we could see that one part of the data was significantly better than the other parts (after hour 21) The part of the data that gave us the best result was when the object appeared to be moving in the east/west direction at its highest point. This is because the two telescopes on the roof are separated from each other in the east/west direction and when Cas A was moving in the east-west direction at the lowest point above the horizon, there were other objects (hills, buildings) in front of it so the data wasn't good. We know that with our power spectrum for Cas A we should see fringes around -0.2 and 0.2 Hz because we know we should be observing the 21 cm line.
Here our our 'sanity check' graphs. The spectrum for Cas A shows clear fringes at -0.2 and 0.2 Hz:

Figure 1: 'Sanity check' graph testing with short sun observation

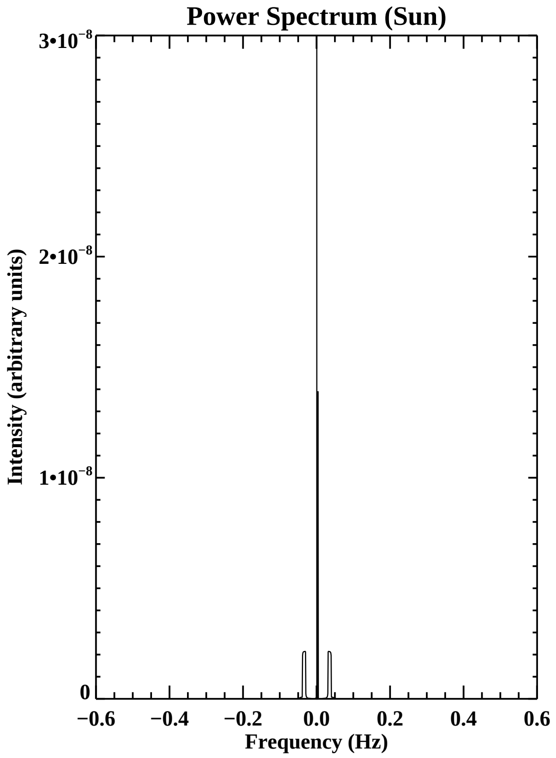
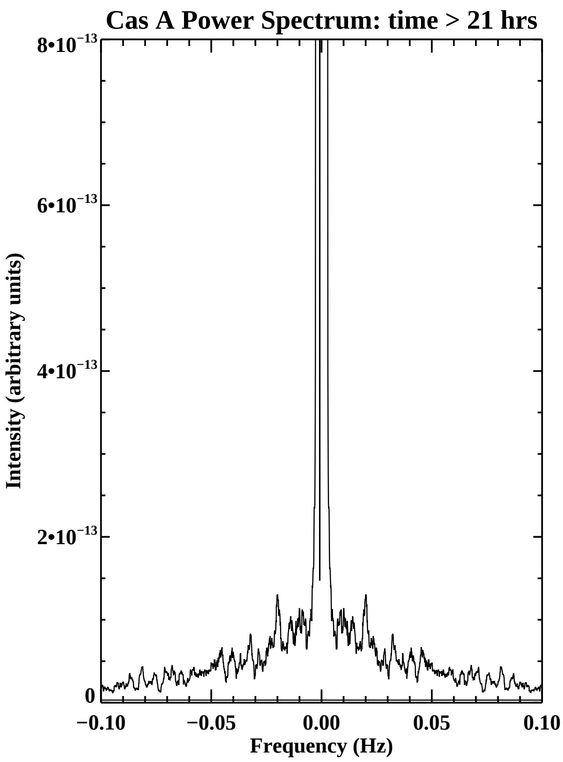



Figure 2: Cas A power spectrum with clear fringes around -0.2 and 0.2 Hz



## Cas A Calculations:

From our observations of Cas A, the goal is to calculate the baseline and the declination. We do this using non-linear least squares fitting. We do this using the brute force technique. Since we know the baseline is mostly in the east-west direction, we can assume that the baseline in the north-south direction is zero. We can then solve for the best value $Q_{ew}$. After this we do the same for $Q_{ns}$ and find the minimum using both values.

## Second Observations: Sun and Moon

We observed the sun and the moon similarly to how we observed Cas A, only for these instead of typing in the RA and DEC, we simply looked up the times the Sun and Moon would be rising/setting and used the follow function in order to track and take data. To compare the Sun and Moon to the data from Cas A, here are the power spectra:

Figure 3: Power Spectrum of the Sun Using Full Data

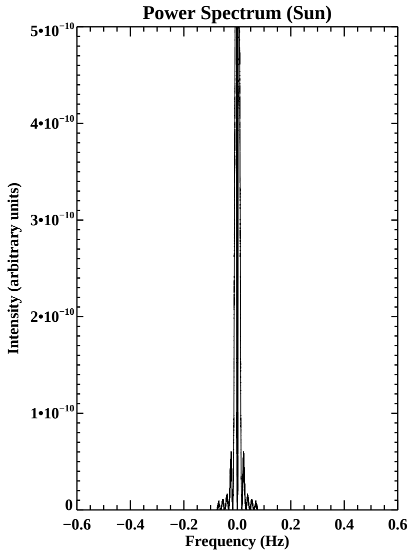



Figure 4: Power Spectrum of the Moon Using Full Data