

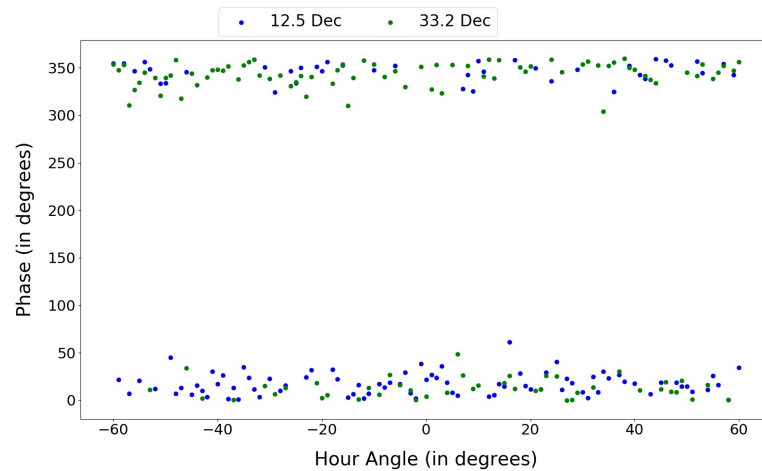
# Homework Set 7 - PHYS 728 Radio Astronomy

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## Abstract

This is the report on my methodology for determining  $\Delta B_x$ ,  $\Delta B_y$ , and  $\Delta B_z$  from two datasets which were given. The results of this are that  $\Delta B_x = -.155$  m,  $\Delta B_y = -.044$  m, and  $\Delta B_z = -1.565$  m, respectively. The theory subtracted data is plotted below.



**Problem 7.1:** The figure below displays the phase at 5 GHz as a function of hour angle (from  $-60^\circ$  to  $60^\circ$ ) for two different sources, one at  $12.5^\circ$  declination and one at  $33.2^\circ$  declination. The phases were measured with a baseline error ( $\Delta B_x$ ,  $\Delta B_y$ ,  $\Delta B_z$ ), but no source position error. Using any means you wish, determine the baseline error from the data (i.e. determine the values of  $\Delta B_x$ ,  $\Delta B_y$ , and  $\Delta B_z$ , in m) and plot the corrected data as a function of hour angle (scale your plot from 0-360). Describe the method you used to find the baseline error. Note: when you plot your corrected data, the phases should be flat, but not necessarily zero. You may require the IDL MOD function to keep your phase correction between 0 and 360. Hint: Look at the dependence of Eq. 3 of lecture 9 on hour angle.

**Solution:** For this problem, I started by finding  $\Delta B_x$ . This was accomplished by first taking the data for the  $12.5^\circ$  declination source, and setting  $\Delta B_z$  to the value at hour angle of zero. This is, of course, not the true  $\Delta B_z$ , but is being used as an initial guess. I then took the even part of the data, and searched through an array of possible  $\Delta B_x$  on  $[-10, 10]$  and found the value which returned the smallest sum of squares. It should probably be noted that the density of this range array did play a significant role in finding the smallest  $\Delta B_x$ . Since we're only using the even part,  $\Delta B_y$  does not have to be determined yet. It was set to zero for simplicity.

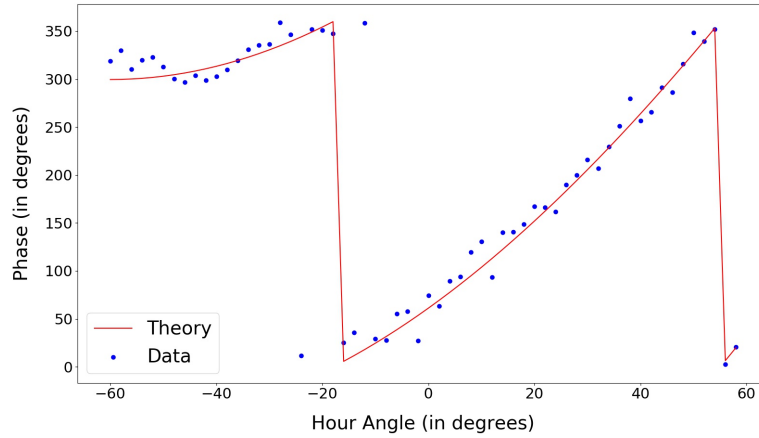


Figure 1: Pictured above is the even part of the data as compared to the even part of the theoretical values produced when a value of  $\Delta B_x = -.155$  and  $\Delta B_z = .659$  is used.

The second step was to take the odd part of the data at  $12.5^\circ$  declination and determine  $\Delta B_y$  using the same method as for  $\Delta B_x$ .

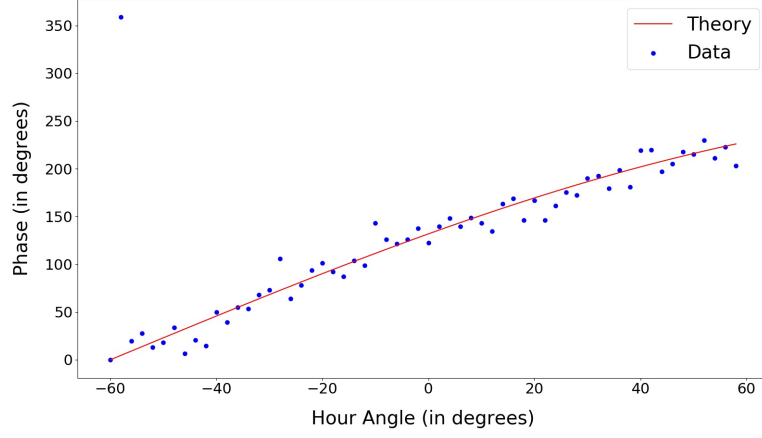


Figure 2: Pictured above is the odd part of the data as compared to the odd part of the theoretical values produced when a value of  $\Delta B_y = -.045$  is used.  $\Delta B_z$  does not affect the odd part of the data.

Then, for the  $12.5^\circ$  declination data, we have the match that has been plotted below.

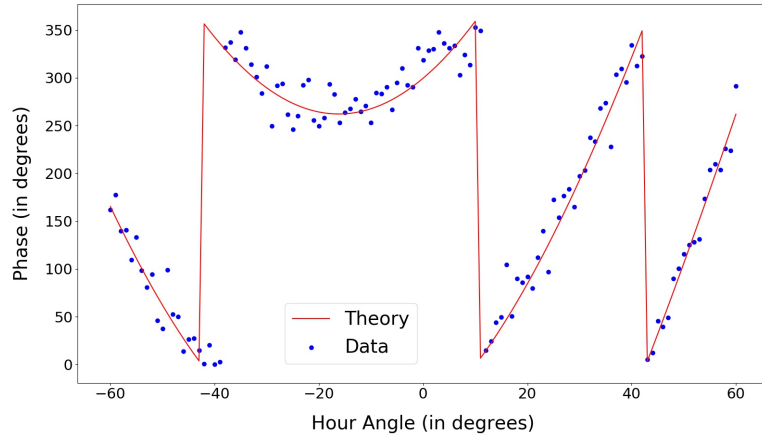


Figure 3: Pictured above is the  $12.5^\circ$  declination data as compared to the theory when a value of  $\Delta B_x = -.155$ ,  $\Delta B_y = -.045$ ,  $\Delta B_z = .659$  is used.

Now, of course, we must determine  $\Delta B_z$ , which was significantly more challenging than I had anticipated, and I found multiple minimums which can satisfy this, which I will explain. If we take the current values and plot them against

the  $33.2^\circ$  declination data, we of course do not get a match. Since  $\Delta B_z$  is related to the phase offset, there are periodic values which satisfy either the  $12.5^\circ$  declination or  $33.2^\circ$  declination individually. The goal is to find one which matches both of them to within a reasonable error.

This process began by assuming that the  $\Delta B_x$  and  $\Delta B_y$  determined by the above process are correct for both declinations. Then, I created an array of possible  $\Delta B_z$  values ranging from  $[-2,2]$ . I set this limit because there were several other possible values for  $\Delta B_z$  in the  $[-10,10]$  range, so I assumed that  $\Delta B_z$  had to be less than two. A third, lower declination value would remove this ambiguity. If we plot the least squares values for both declinations for this range of  $\Delta B_z$  values, we get the plot shown below.

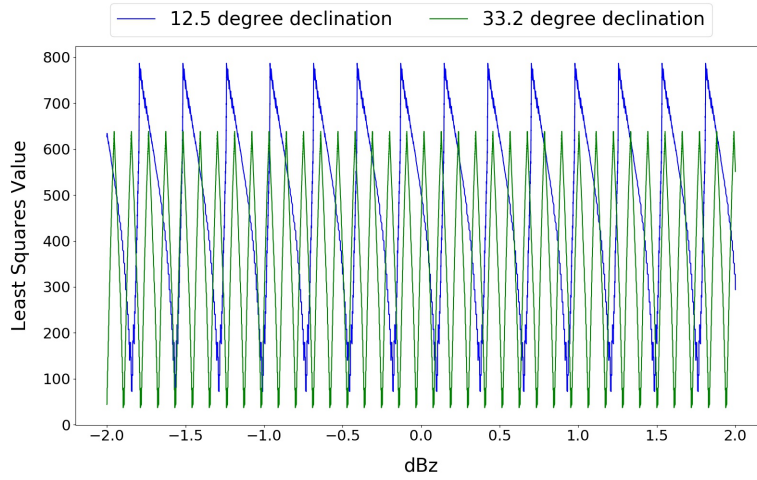


Figure 4: Pictured above is the least squares comparison between the  $12.5^\circ$  and  $33.2^\circ$  declination data when values of  $\Delta B_x = -.155$  and  $\Delta B_y = -.045$  are used. As can be seen, the minimum least squares values match up as specific values of  $\Delta B_z$ .

The best match found within this range was at  $\Delta B_z = -1.565$ , which is plotted below in a zoomed window of Figure 4.

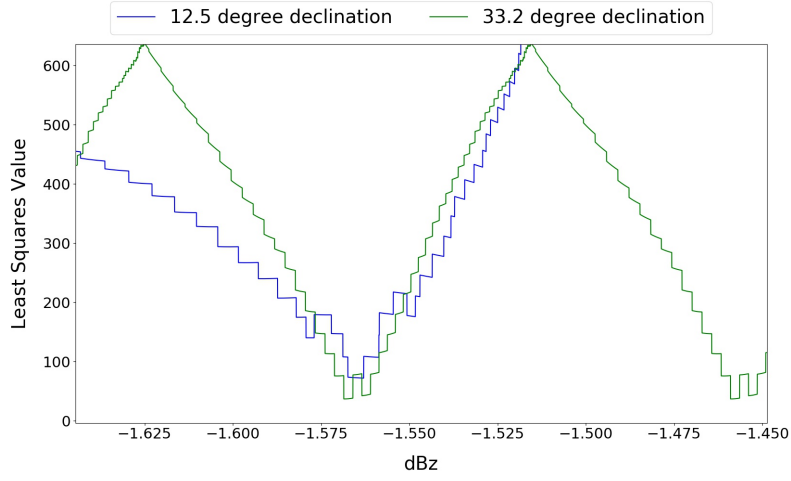


Figure 5: Pictured above is a zoomed in window of Figure 4, about the location where the most likely  $\Delta Bz$  is located. Others values were close, but this one showed the best match between the two data sets.

From this analysis, it was determined that  $\Delta Bz = -1.565$ . It should be noted that a small error in  $\Delta Bx$  could significantly alter this result, but I couldn't get my shuffling program to work correctly in order to search around  $\Delta Bx$  values when a  $\Delta Bz$  had been selected.

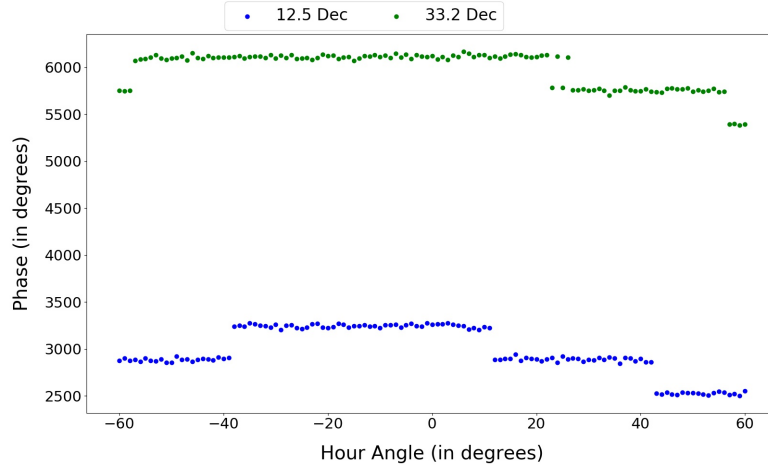


Figure 6: Pictured above is the data with the theory removed, but this data has not been subjected to a modulo function, as the data in the first plot was.