Homework Set 7 - PHYS 728 Radio Astronomy

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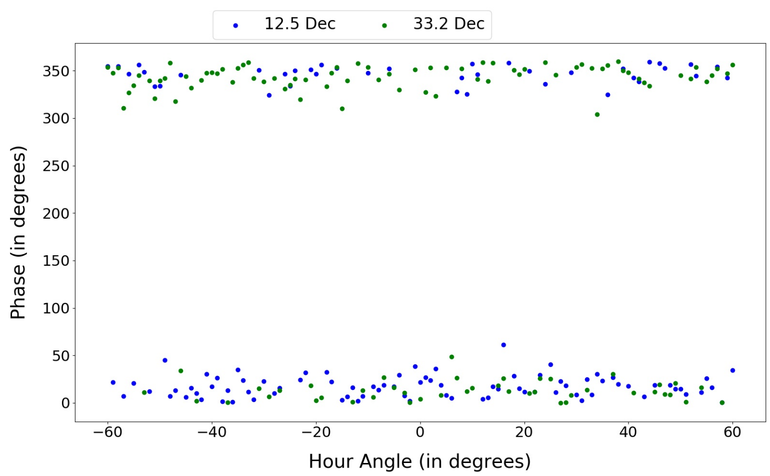
Abstract

This is the report on my methodology for determining $\triangle$Bx, $\triangle$By, and $\triangle$Bz from two datasets which were given. The results of this are that $\triangle$Bx = -.155 m, $\triangle$By = -.044 m, and $\triangle$Bz = -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° to 60°) for two different sources, one at 12.5° declination and one at 33.2° declination. The phases were measured with a baseline error ($\triangle$Bx, $\triangle$By, $\triangle$Bz), but no source position error. Using any means you wish, determine the baseline error from the data (i.e. determine the values of $\triangle$Bx, $\triangle$By, and $\triangle$Bz, 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 $\triangle$Bx. This was accomplished by first taking the data for the 12.5° declination source, and setting $\triangle$Bz to the value at hour angle of zero. This is, of course, not the true $\triangle$Bz, but is being used as an initial guess. I then took the even part of the data, and searched through an array of possible $\triangle$Bx on [-10, 10] and found the value which returned the smalled sum of squares. It should probably be noted that the density of this range array did play a significant role in finding the smallest $\triangle$Bx. Since we're only using the even part, $\triangle$By does not have to be determined yet. It was set to zero for simplicity.

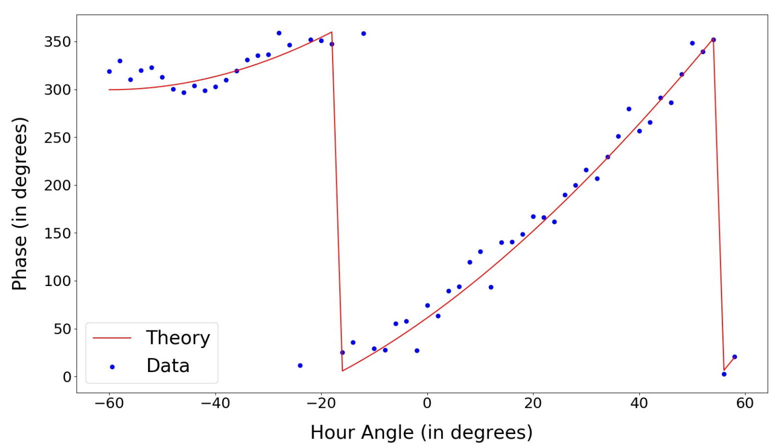


Figure 1: Pictured above is the even part of the data as compared to the even part of the theoretical values produced when a value of $\triangle$Bx= -.155 and $\triangle$ Bz= .659 is used.

The second step was to take the odd part of the data at 12.5° declination and determine $\triangle$By using the same method as for $\triangle$Bx.

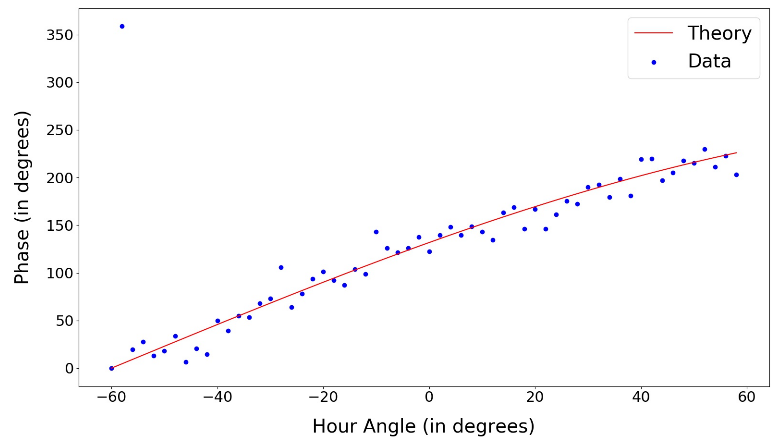


Figure 2: Pictured above is the odd part of the data as compared to the odd part of the theoretical values produced when a value of $\triangle$By = -.045 is used. $\triangle$Bz does not affect the odd part of the data.

Then, for the 12.5° declination data, we have the match that has been plotted below.

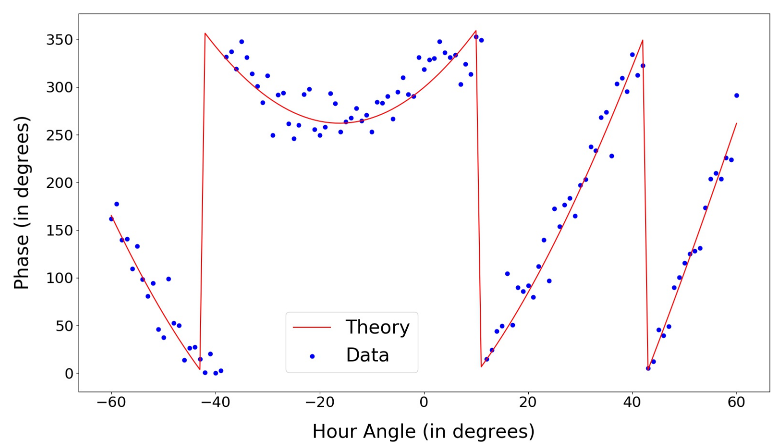


Figure 3: Pictured above is the 12.5° declination data as compared to the theory when a value of $\triangle$Bx= -.155, $\triangle$By= -.045, $\triangle$Bz= .659 is used.

Now, of course, we must determine $\triangle$Bz, 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° declination data, we of course do not get a match. Since $\triangle$Bz is related to the phase offset, there are periodic values which satisfy either the 12.5° declination or 33.2° 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 $\triangle$Bx and $\triangle$By determined by the above process are correct for both declinations. Then, I created an array of possible $\triangle$Bz values ranging from [-2,2]. I set this limit because there were several other possible values for $\triangle$Bz in the [-10,10] range, so I assumed that $\triangle$Bz 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 $\triangle$Bz values, we get the plot shown below.

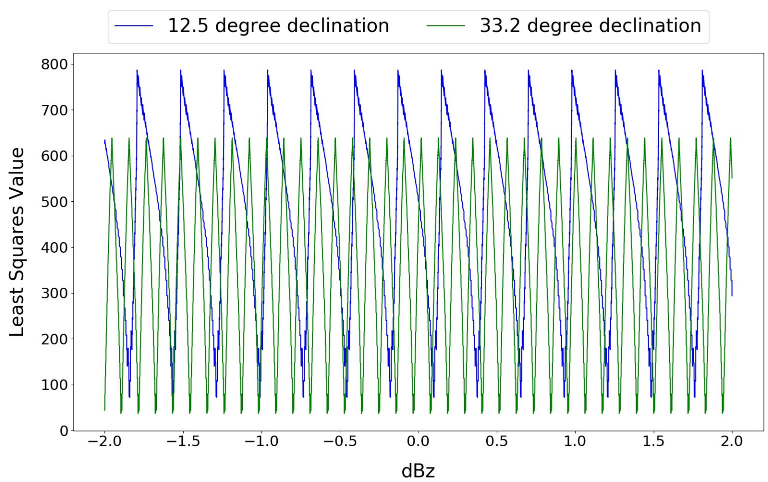


Figure 4: Pictured above is the least squares comparison between the 12.5° and 33.2° declination data when values of $\triangle$Bx = -.155 and $\triangle$By = -.045 are used. As can be seen, the minimum least squares values match up as specific values of $\triangle$Bz.

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

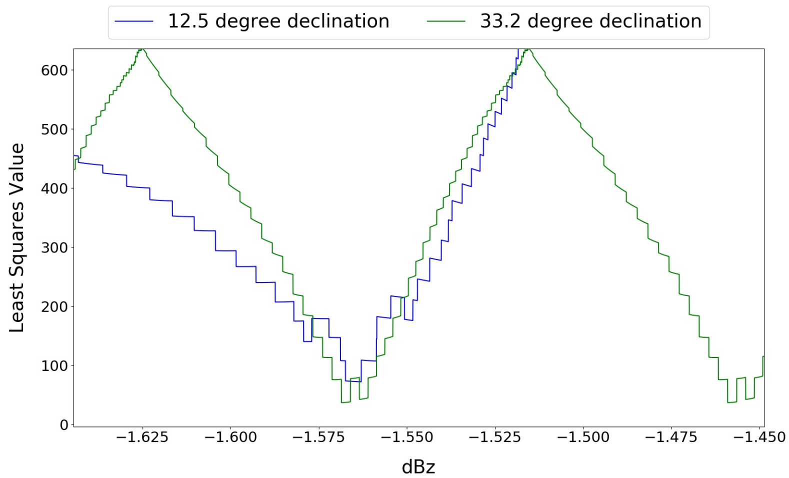


Figure 5: Pictured above is a zoomed in window of Figure 4, about the location where the most likely △Bz is located. Others values were close, but this one showed the best match between the two data sets.

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

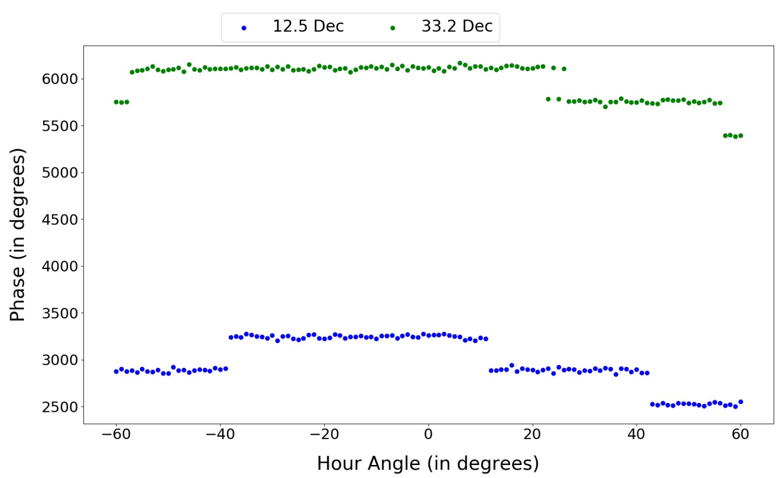


Figure 6: Pictured above is the data with the theory removed, but this data has not been subjected to a modulo function, as the data in the first plot was.