Determination of the Pointing Offsets and Beam

Pattern for the 3-m Telescope

1 Goal of the experiment

The aim of this experiment is to align the 3-m telescope at NCRA East campus with the astronomical horizon coordinate system (altitude/azimuth system) allowing it to be pointed correctly to a given astronomical source. This requires determining the offsets between the electronic reference of the telescope and the astronomical ALT/AZ coordinate system at the observatory. Using the calculated offsets, scans in AZ and AL direction are taken to calculate the Beam-Width of the 3-m Telescope.

The understanding of the issues of practical astronomy is tested by the brain teaser section, which requires solutions to problems listed in this sheet and familiarization with directions in sky.

The procedure for the initialization of the telescope and receiver should be followed first. This is given in a separate instruction document. The procedure in this document describes the operation of the telescope and receiver system to perform this experiment, which requires solar observations to determine azimuth and altitude offset and antenna beam. The observation section provides a log sheet for the experiment. It is followed by an analysis section, which consists of analysis procedure and log. Finally a results section is provided for listing results alongwith the errors.

2 Brain Teaser

1. Go out on the terrace and identify different directions on the sky. If sun is visible, roughly find the direction of North pole, which is one of the reference for telescope control system. Indicate approximately the Alt-azimuth position of the telescope.

Ans.:

2. Track the path of the Sun on the sky. How does the azimuth and altitude change through the day at NCRA campus? How this change would if you were located +50 N at the time of the experiment? How this change would if you were located -50 N at the time of the experiment?

Ans.:

3. Estimate the RA/Dec of Sun and find out the constellation in which the Sun would be located at the time of observation. Familiarize yourself with the equatorial coordinate system as it is visible from the telescope location. In what direction then RA/Dec increases/decreases? Where is the 0,0 RA/Dec point located in the sky?

Ans.:

4. Indicate the approximate time of rise and set in IST today when the sources with following RA and Dec can be observed using our 4-m telescope at NCRA East Campus. (Assume that the sky 17degree above horizon is visible with the telescope)

5. Compare the angular size of Sun disk and the beam width of the telescope? What is the resolution of a typical optical telescope (let's assume D=10cm)? What should be the diameter of the telescope at 21 cm, to achieve the same resolution?

Ans.:

3) Experimental Procedure

1) Find out the expected Right Ascension and Declination of the Sun during the time of your experiment (preferably on the night before the experiment). Convert this to horizon coordinates (altitude and azimuth). Note these in the following table.

   RA =

   Dec =

Time	Alt	Az
08:00		
08:05		
08:10		
08:15		
08:20		
08:25		
08:30		
08:35		
08:40		
08:45		
08:50		
08:55		
09:00		

2) Do the initialization of the telescope control and receiver as explained in the document "Initialization of 3-m telescope". This experiment can be done by pointing the antenna approximately at Sun visually if the sky is not cloudy. To do this, rotate antenna approximately in the direction of the Sun (using AZEL) and look for the shadow of the feed at the center of the dish. Rotate the antenna till the shadow is centered approximately. This method will not work if there are clouds or the altitude is too high, in which case you should use the calculated altitude/azimuth of the Sun.

3) Start the receiver and do the settings as per the following tables (using commands given in step 16 of the initialization procedure

Mode	continuum
Integration	0.3
IF BW KHz	30KHz
Target Name	File name

Where Filename should be SunBatchn (n=1/2/3/4/5)

Parameter	Values
IF Gain	12db
DC gain	1
DC offset	1.5

Time/step	0.2
Source Name	File name

4) Start a scan (STRTS) . Move the antenna left or right, up and down by 30 degrees and try to get maximum power of sun on the screen of receiving computer (spectra cyber s/w).

5) Note down the power at maximum and try smaller moves till you locate the altitude/azimuth of the direction where the power is maximum.

6) Move the antenna to this position, which is the altitude/azimuth of the Sun

7) Estimate the motion of Sun during your experiment duration (typically 15 min) and correct the position obtained in 5 by half of Solar motion during the experiment. Note this position as well as the starting time of the experiment in the observation log.

8) Move the antenna in azimuth 3 degrees less than azimuth obtained in 6 keeping the elevation same as that obtained in 6.

9) Start a scan and record about 60 points. Stop the scan and save the scan. Note that the file name is formed from the file name (target name) given in 2 and UTC so is unique for each scan . Note this filename and time of experiment in the observation log

10) Move azimuth axis by 0.5 degree and repeat 8 and 9 till an azimuth greater than 4 degrees than that calculated in 6 is reached. Elevation is kept constant. Step 7, 8 and 9 give a scan across Sun in azimuth and will result in 14 data files, each consisting of 60 data points. Note the name of each file in the observation log for later reference. The filename should start with batchn (where n is the number of batch) for you to find the file corresponding to your batch.

11) Move to altitude and azimuth of Sun (calculated in 6). Repeat 7, 8 and 9, this time keeping azimuth constant and starting from lower altitude to higher altitude. This gives an altitude scan with 14 data files. Note the names of the files in the observation log.

12) If time permits, more azimuth and altitude scan can

13) Note down the following things carefully in the observation log:
- i) Start angle in azimuth and elevation
- ii) Start time in both azimuth and elevation

This will be required during data analysis.

5 Observation Log

1. Azimuth Scan
   Altitude :

Serial no	Time	Azimuth	File Name UTC
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

2. Altitude Scan
   Azimuth :

Serial no	Time	Altitude	File Name UTC
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

4) Procedure for analyzing the data

1) Copy all the data files in pen-drive and transfer it analysis PCs.
2) Create a folder and save the data files with .txt extension.
3) Each data file has a header which gives the time of observations followed by a column of data.
4) Copy data column from each data file In a column of excelsheet.
5) Find the average of the column and its standard deviation . This gives the output of the at the altitude and azimuth where the telescope was pointing as well as the measurement error.
6) Repeat this for all 14 files of the scan and prepare a text file using notepad which gives altitude/azimuth in the first column, intensity in the second column and error in the third column. Save this file as "altscan" or "azscan".
7) Start MATLAB by clicking on the MATLAB icon. A window, similar to that shown below , will open up.
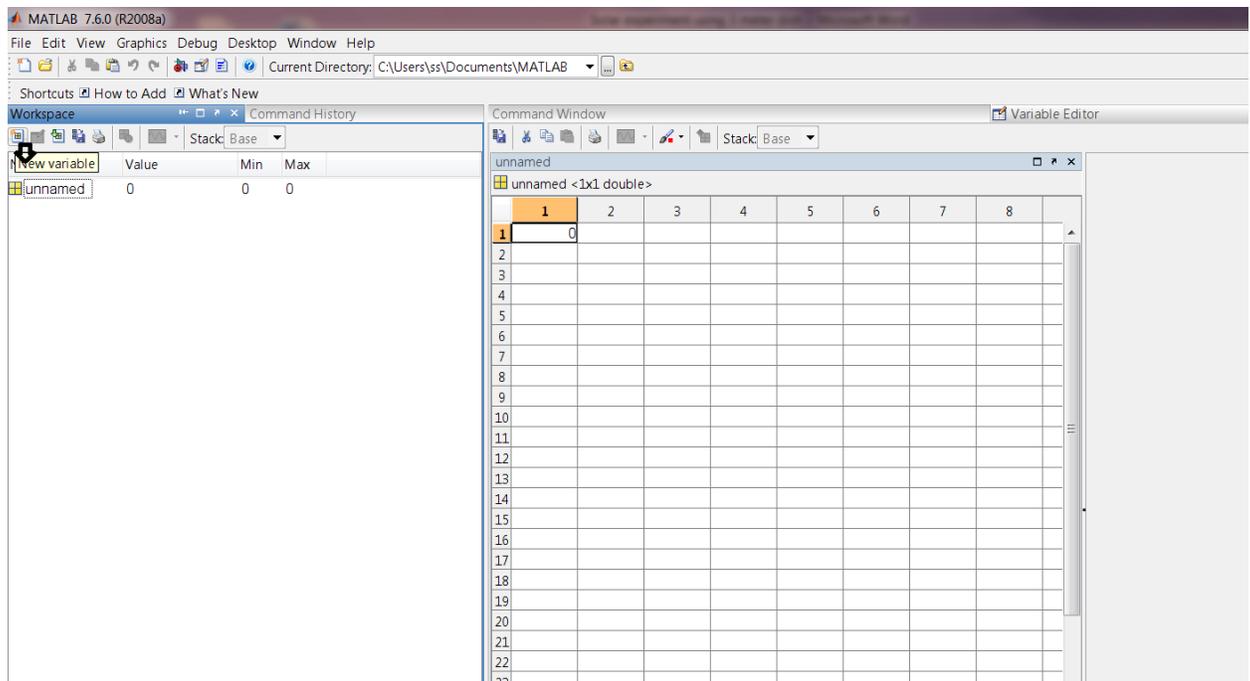
Fig3 MATLAB screen

8) Load the file prepared in 6
   ```
   >> load "azscan"
   >> x= azscan(1,*)
   >>y=azscan(2,*)
   >>err=azscan(3,*)
   ```

9) Plot the data
   >> plot(x,y)
   A plot will appear on the screen.
10) Fit the data to the following model using curve fitting tool box
   Y(x) = A * exp(-((x-B)/C)^2) + D
   >> cftool
11) This will open a curve fitting A window will appear as shown below
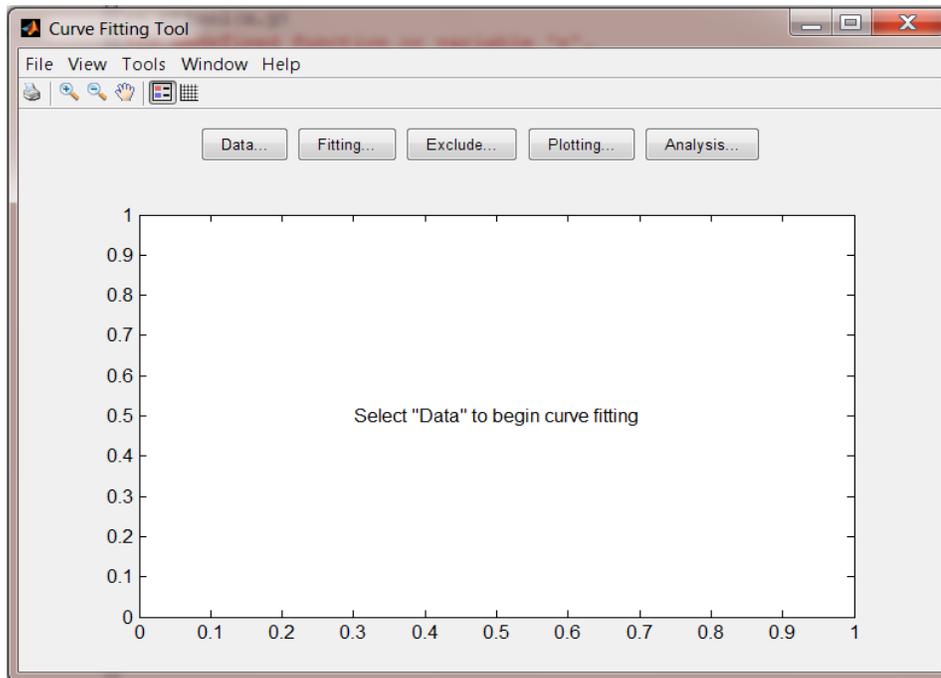
Click on the

Fig 4 curve fitting window

fitting icon - a fit editor will appear – click on new fit – browse on type of fit – click on custom equation – click on new (a new custom equation window will appear) – go to the general equation and click on that. Give your model

Y=a1*exp(-((x-b1)/c1)^2)+d1.

This is a fit to a Gaussian beam , where A gives the amplitude of the Gaussian, B gives the position of the maximum (position of Sun in degrees), C is related to the full width at half maximum (beamwidth of the antenna in degrees) and D is a constant. Provide an approximate value for A, B, C and D by looking at the plot in 9. Click on apply. A Gaussian model will be fitted to the data and the fit will be shown. A more accurate fit also uses the error in "err" Matrix.

Note down values of the fitting parameter a1,b1,c1,. Parameter b1 = Mean = peak of Gaussian

12) Note down the values of the fitted parameters a1, b1 and c1 in the analysis log.

13) To save the plot obtained in cftool - go to File - print to figure - Insert x label, y label - file- save as - name.jpg or name.pdf - save

14) Attach fitted plots and write the following log

Please note that the same analysis can also be carried out using "octave" in linux (which is similar to MATLAB) or "gnuplot". If you are familiar with these packages, you can use these as well. Ask the instructor for help. Please note that the licenses for MATLAB are limited to 5. Hence, please do not lock these licenses when not in use as this will prevent others from using these licenses.

1 Altitude Scans

	Altitude Scan -
Datapoint selected	
Peak of Gaussian (Deg.)	
FWHM of Gaussian (Deg.)	
Expected Azimuth Deg	
Expected Altitude Deg	
Measured Altitude	
Offset	

2 Azimuth scan

	Azimuth scan -
Datapoint selected	
Peak of Gaussian (Deg.)	
FWHM of Gaussian (Deg.)	
Expected Azimuth Deg	
Expected Altitude Deg	
Measured Azimuth	
Offset	

5) Results and Discussion

The estimates of pointing offsets are as follows -

1. Azimuth Offset :   Deg.

2. Altitude Offset :   Deg.

The Beam-Width of the 3-m telescope is the FWHM obtained from the

beam pattern as -

3. Beam-Width: Deg.

4.The theoretical expected value of Beam-Width: Deg.

The sources of error in my experiment are as follows