Detecting Galactic HI line using 3-m SRT

1 Goal of the experiment

The goal of the experiment is to detect the galactic HI line emission and to understand the physics behind it. In this experiment, we will observe the emission from neutral hydrogen (HI) present in our Galaxy, Milky Way. This emission occurs at 21 cm (1420 MHz) and arises due to the transition between the hyperfine splitted ground state of the hydrogen atom. The experiment involves positioning the telescope at a given point along the Galactic plane and taking the spectrum towards the pointed direction. The line may occur at a frequency different from the rest frequency due to relative motions between the source and the telescope. The spectrum thus obtained can be then analyzed to measure the line strength, width and position, which encode information about the kinematics and dynamics of our Galaxy.

2 Brain Teaser

1. What is the distance of the sun from the center of our galaxy? How the plane of the galaxy, plane of the solar system and plane of the revolution of the earth and the axis of rotation of the earth are linked with one another? Estimate maximum speed of the earth due to all these motions? How much Doppler shift will this motion be responsible for (if an observer decides to receive an signal from a stationary source outside our galaxy)?

2. Our galaxy - Milky way - forms a bright band in the sky visible on a dark night. Find out how the galaxy lies in the sky at the time of the experiment and draw it approximately in the space provided below by showing directions. Indicate whether the Galactic center, which is believed to harbour a supermassive black hole, is visible at the time of the experiment.

Ans.

3. Three strong radio sources are CRAB, CASA and CYGA. Which constellations harbours these? Indicate below the names of the constellations and whether these sources are visible at the time of experiment. If yes, find the area of sky where these will be located.

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

RA	Dec	Time(IST)
01h 30m	+30 deg20 min	
05h 31m	+21 deg10 min	
04h 37m	-56 deg01min	
17h 10m	-30 deg23 min	
21h 05m	+40 deg21 min	

3. Experimental Procedure

The experiment involves observations of a few selected points along the Galactic plane with 0 degree Galactic latitude. The list of some standard strong radio sources is given below. The Table 1 gives coordinates of 4 of the IAU calibrators (i.e. their brightness temperature (Tb) is accurately known - Williams, 1973) and can be used for the HI detection experiment as well as for determining the system temperature (Tsys). The sources given in Table-2 are the points on the galactic plane and can be used for mapping the Galactic HI emission.

Source	Tb(K	RA	DEC
S9	85±6	17h 52m 05s	-34d 28m 42s
S8	72±5	05h 47m 21s	-01d 40m 18s
S7	100±7	02h 06m 13s	+60d 32m 52s
S6	51±4	15h 31m 34s	-02d 25m 09s

Table 1: Coordinates of HI bright IAU calibrators sources, in J2000 Epoch.

Sources name	Gal Long(deg)	RA	DEC
P01	0.00	17h 42m 26	-28d 55m 00s
P02	30.00	18h 43m 28	-02d 39m 46s
P03	45.00	19h 11m 20	+10d 38m 13
P04	60.00	19h 41m 47	+23d 46m 10
P05	75.00	20h 19m 02	+36d 26m 45
P06	90.00	21h 10m 18	+48d 07m 24s
P07	105.00	22h 28m 06	+57d 36m 13s
P08	120.00	00h 23m 01	+62d 26m 55s
P09	135.00	02h 28m 10	+60d 16m 29s
P10	150.00	04h 00m 39	+52d 17m 01s
P11	165.00	05h 00m 42s	+41d 16m 57s
P12	180.00	05h 42m 26	+28d 55m 00
P13	195.00	06h 14m 58	+15d 55m 24s
P14	210.00	06h 43m 28	+02d 39m 47s
P15	240.00	07h 41m 47	-23d 46m 10s
P16	270.00	09h 10m 18s	-48d 07m 24s
P17	300.00	12h 23m 01s	-62d 26m 55s
P18	330.00	16h 00m 39	-52d 17m 00s

Table 2: Source coordinates along the Galactic plane in 1950 Epoch.

The source position is given in the Equatorial Coordinates (RA,DEC) in 1950 epoch. These coordinated are fed to the software and the objects are visible on the map visible on the software screen. The telescope can be pointed to these sources by simply clicking on the name of the source. The procedure for the experiment is given below

1. Please read the document titled "Initialization and operation of 3-m telescope" and familiarize yourself with the instructions given there. **In particular, read the "PRECAUTIONS" carefully and please follow these diligently.**
2. Switch on the drives and take the telescope to home position, which is Az=0 Al=10.
3. Switch on the receiver and the personal computer
4. The settings of the receiver for this experiment are as follows
   click and browse the setting **for H1 line in spectral mode**

Mode	spectral
Integration time	1 sec
IF BW KHz	15 KHz
Target Name	File name

   Where filename should be HIbatchn (n=1/2/3/4/5 depending on the batch)

   Options – click on "online "

   Do the following setting for spectral mode

Parameter	Values
IF Gain	24

DC gain	1
DC offset	1.5
Time/step	1
Upper limit	2000
Lower limit	-2000
Source Name	Name

5. Set the antenna offsets as calculated from the Experiment 1. Press offset button followed by typing azoffset eloffset.
6. Click on the source on the sky map. The antenna will start slewing to the source
7. After antenna is pointing to the source, start scan by clicking on the scan icon in the receiving computer.
8. Check the spectrum. One should see the strong H1 line on the screen.
9. If the line is not visible, check if you have followed the procedure correctly, entered the offsets
10. If the line is visible, then recording data by putting autosave on. Check that the data is being recorded to the right filenames. Save 2,3 scans for each source.
11. Repeat the procedure for each of the source in Table 1 and 2. Record thedata in a separate file And fill the file names in the observation log.

4 Observation Log

1. Source & Data file name :

2. Source & Data file name :

3. Source & Data file name :

4. Source & Data file name :

5. Source & Data file name :

6. Source & Data file name :

7. Source & Data file name :

8. Source & Data file name :

9. Source & Data file name :

10. Source & Data file name :

11. Source & Data file name :

12. Source & Data file name :

13. Source & Data file name :

14. Source & Data file name :

15. Source & Data file name :

16. Source & Data file name

5. Analysis Procedure

1. Copy the data file from the PC where you recorded data to the pc where MATLAB is installed **(Equivalently you can analyse the data in "octave" or 'gnuplot").**

2. Save the data file as a text file with a name such as "p1h" or "p2h" etc.

3. Click on MATLAB. go to new variable as shown bellow fig

4. Remove the first line and copy /export the data to the MATLAB editor in the first row

5. Give some name to the folder in the work space e.g. p1 etc.

6. write the following command in command window for plotting the data

>>(your folder name)' e.g p1' -----this command will convert your data from column to row

Create a x array as

>> for i=1:400

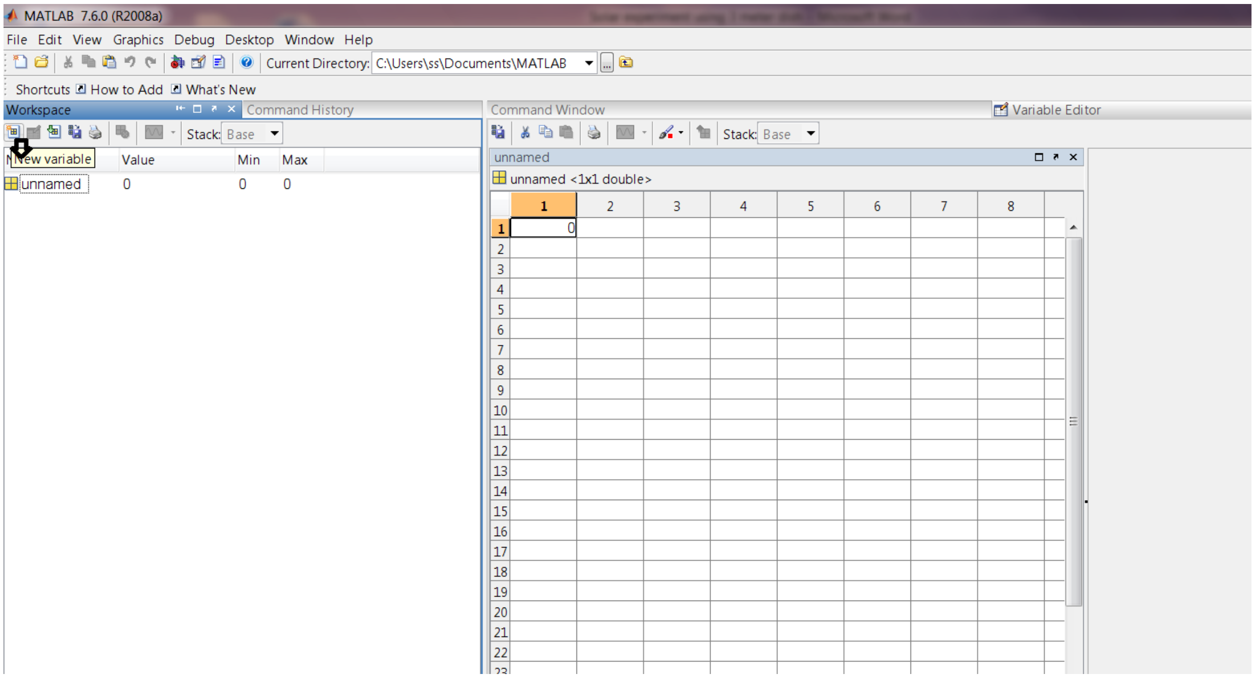
X(i) = 0.211*(1-201)*4 end

Create a y array as

For i=1:400

Y(i)= your folder name(i) end

>>plot(x,y)----------this will plot the data.



3.2 Log

1. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :------------ km/s ±

(d) FWHM of Gaussians :------------- km/s ±

(e) Peak of Gaussians :---------------- km/s ±

(f) Residual Chisq :

2. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :----------------- km/s ±

(d) FWHM of Gaussians :------------------- km/s ±

(e) Peak of Gaussians : ---------------------km/s ±

(f) Residual Chisq :

3. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :------------- km/s ±

(d) FWHM of Gaussians :------------- km/s ±

(e) Peak of Gaussians :-------------- km/s ±

(f) Residual Chisq :

4. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :------------------ km/s ±

(d) FWHM of Gaussians :--------------------- km/s ±

(e) Peak of Gaussians :------------------------- km/s ±

(f) Residual Chisq :

5. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :------------------- km/s ±

(d) FWHM of Gaussians :-------------------- km/s ±

(e) Peak of Gaussians :----------------------- km/s ±

(f) Residual Chisq :

6. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :----------------- km/s ±

(d) FWHM of Gaussians :----------------- km/s ±

(e) Peak of Gaussians : ---------------------km/s ±

(f) Residual Chisq :

7. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :---------------- km/s ±

(d) FWHM of Gaussians :--------------- km/s ±

(e) Peak of Gaussians:--------------------- km/s ±

(f) Residual Chisq :

8. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians : --------------------km/s ±

(d) FWHM of Gaussians :--------------------- km/s ±

(e) Peak of Gaussians :--------------------------- km/s ±

(f) Residual Chisq :

9. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians :---------------------- km/s ±

d) FWHM of Gaussians : ---------------------------km/s ±

(e) Peak of Gaussians : --------------------------km/s ±

(f) Residual Chisq :

10. Source :

(a) Baseline fit parameters :

(b) No of Gaussians required :

(c) Position of Gaussians : -----------------km/s ±

(d) FWHM of Gaussians :------------------- km/s ±

(e) Peak of Gaussians : -------------------------km/s ±

(f) Residual Chisq :

4 Results and Discussion

Calculate the doppler velocity from the spectrum of the sources observed. Discuss the nature of the spectrum and its features. Comment on the velocity calculated and the location of these sources on the galactic plane. Discuss the factors responsible for the doppler shift of your spectrum. Give the sources of error and explain the results.