

Detecting Galactic HI line using the 4-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 split 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. A shift in the line from its rest frequency is expected. The observed shift may either be redshift or blue shift and will depend on the position of the observed source on the Galactic plane. The spectrum thus obtained can then be analyzed to measure the line strength, width and position.

2 Procedure for the experiment

Before starting with the experiment, initialization of the telescope has to be done.

The experiment involves observations of a few selected points along the Galactic plane with 0 degree Galactic latitude. The sources given in Table-3 are the points on the galactic plane and can be used for mapping the Galactic HI emission.

The source position is given in the Equatorial Coordinate System (RA,DEC) of 1950 epoch. Precess the coordinates to the epoch of your observation and convert it to Horizontal coordinates to get the position of the source at a given time. The telescope can be pointed to these sources by rotating it in both axes.

The procedure for the experiment is given below:

Source name	Galactic longitude (deg)	RA	Dec
P01	0.0	17h 45m 26s	-28 ⁰ 56' 00"
P02	30.0	18h 46m 28s	-02 ⁰ 36' 46"
P03	45.0	19h 13m 20s	+10 ⁰ 43' 13"
P04	60.0	19h 43m 47s	+23 ⁰ 53' 10"
P05	75.0	20h 20m 02s	+36 ⁰ 36' 45"
P06	90.0	21h 12m 18s	+48 ⁰ 19' 24"
P07	105.0	22h 29m 06s	+57 ⁰ 51' 13"
P08	120.0	00h 25m 01s	+62 ⁰ 43' 55"

Table 3: Source coordinates along the Galactic plane in 1950 Epoch

Mode	Spectral
Integration time	1 sec
IF BW KHz	30 KHz
Target Name	File Name

Table 4: Spectral mode selection steps

Parameter	Values
IF Gain	15.00
Spectral Gain	5
Spectral Offset	2.20
Upper limit	+2000
Lower limit	-2000
Time/step	0.2
Source name	Name

Table 5: Settings for spectral mode

1. Switch on the receiver and the personal computer (Rx and RPC)
2. Open “**Mbus_az.exe**” and “**Mbus_alt.exe**” on receiver PC.
3. Change the settings of ‘**Mbus_az.exe**’ and ‘**Mbus_alt.exe**’ as given in the initialization document.
4. Rotation of the antenna can be done by changing the value corresponding to address “**40001**” to **2** or **3** and click “**write**” for either of the axis.
Note: For **azimuth** value **2** rotates the antenna in **clockwise** and value **3** rotates the antenna **counter clockwise**. For **elevation** value **2** rotates the antenna **upwards** and value **3** rotates the antenna **downwards**.
5. Stop the rotation once you reach the position for your observation by changing the value corresponding to address “**40001**” to either **10** or **11** for either of the axis.
6. The settings of the receiver for this experiment are as follows click and browse the setting for H1 line in spectral mode “Settings-Mode-Spectral”
7. Change the settings for spectral mode as given in table – 5. To change settings click Options – click “online”, where filename should be H1batchn (n=1/2/3/4/5/6 depending on the batch)
8. Find out the Al/Az for the source you have selected at the time of observation.
9. Rotate the antenna and point it towards the source and start scan by clicking on the scan icon in the receiving computer.
10. Check the spectrum. One should see the strong H1 line on the screen.
11. If the line is not visible, check if you have followed the procedure correctly and entered the offsets.

12. If the line is visible, then record the data by putting autosave on. Check that the data are being recorded to the right filenames. Save 2,3 scans for each source.
13. Repeat the procedure for each of the source in Table 3. Record the data in a separate file. Fill the file names in the observation log.
14. Bring the telescope to home position after doing the observations.

3 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 :

4 Analysis Procedures

Analysis with GNUPLOT:

1. To analyze with GNUPLOT one has to generate x axis with the Doppler shift formula which is as follows:

$$\pm V = \frac{\pm \Delta \gamma}{\gamma} * c$$

Where, V is the velocity of approach or recession

C is the speed of light

$\Delta \gamma$ is the frequency shift

γ is the rest frequency for (H1 = 1420.4 MHz)

2. X - axis can be generated as follows:
>> seq -422 2.11 422 > 'outputfilename'
Where -422 corresponds to the least of the bandwidth
+422 corresponds to maximum of the bandwidth
2.11 defines the interval between each points
3. Y – axis is the output file from the receiver 'p1'.
4. Merge the two files together with the help of paste command
>> paste 'outputfilename' 'p1' > 'Newfilename'
5. Plot the graph with the gnuplot as follows:
>> gnuplot
6. gnuplot> plot 'Newfilename' w l
7. Now you can see the plot. One can fit the observation with the best model.
8. To fit the data with the Gaussian by using a Gaussian function as follows:
>> f(x) = a*exp(-((x-b)**2/(2*c**2)))
9. Give the approximate values of a,b,c with the help of the plot.
10. Fit Gaussian using the following command.
>> fit f(x) 'output file name' via a,b,c
11. This will fit the data with the Gaussian function. Note down the value of a, b and c with its error.
12. If you wish to see the fit, plot it using the following command
>> plot 'output file name' w l, f(x)
13. Note down the a,b,c values with errors also note down the reduced chi square value.

5 Log

1. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. f. Residual Chisq :

2. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. Residual Chisq :

3. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. Residual Chisq :

4. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. Residual Chisq :

5. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. Residual Chisq :

6. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. Residual Chisq :

7. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. Residual Chisq :

8. Source :

- a. Baseline fit parameters :
- b. No of Gaussians required :
- c. c. Position of Gaussians : \pm km/s
- d. d. FWHM of Gaussians : \pm km/s
- e. e. Peak of Gaussians : \pm km/s
- f. Residual Chisq :

7 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.