HI 21 cm Line: Significance and Detection

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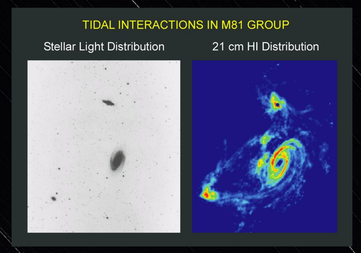
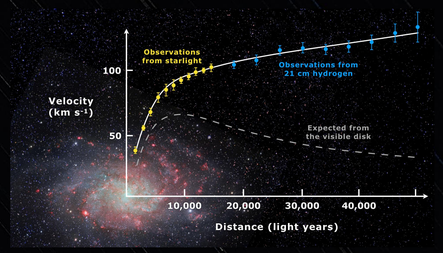
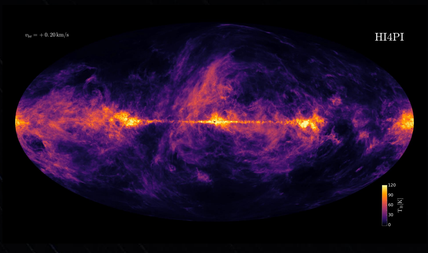
Introduction

The 'Neutral Hydrogen', also known as HI, comprises of 25% of all the baryonic matter. This cold neutral gas is present throughout our galaxy in low density regions of Interstellar Medium (ISM). Although as it is neutral it does not give off neither visible radiation nor it can participate in standard radio wave generation method. But the HI is observed to radiate an electromagnetic wave of frequency *1,420,405,751.766 Hz* which falls in the Microwave region of EM Spectrum. Due to it's sensitivity to gas kinetics, HI spectral emission line plays a very important role in astronomy as it helps to understand the Galactic Dynamics, Galactic Rotation Curves, ISM Dynamics, Doppler Shifts of various astronomical bodies and various cosmological aspects. The HI line also plays a significant role in the relevance to the search for non-human intelligent life.





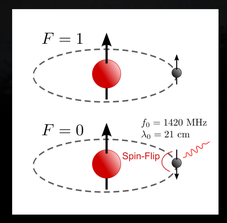


Mechanism of Transition

1. The ground state of neutral hydrogen consists of an electron bound to a proton. Both the electron and the proton have intrinsic magnetic dipole moments ascribed to their spin, whose interaction results in a slight increase in energy when the spins are parallel, and a decrease when antiparallel.
2. Therefore, when both proton and electron are in parallel state, the electron spontaneously flip it's spin to attain the antiparallel states, the lowest energy configuration. In this process, a photon is released of energy 5.874 x 10^{-6} eV.

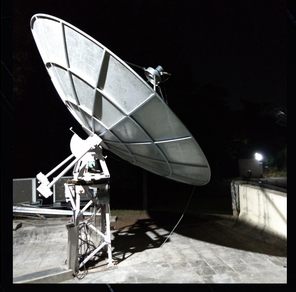
Properties of HI line

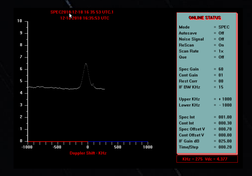
1. **Frequency** - 1,420,405,751.766 *Hz*
2. **Wavelength –** 21.1061140542 cm
3. **Energy of Transition -** 5.874 x 10^{-6} eV
4. **Transition Rate –** 2.85 x 10^{-15} s^{-1}
5. **Mean Lifetime of Transition State -** ~10 million years



Instrumentation

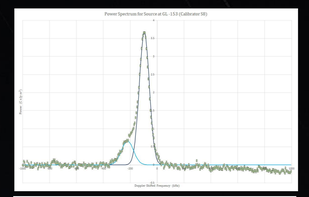
1. 4 m Dish type Simple Radio Telescope with motorised Alt-Az Mount.
2. Band pass filters
3. Low Noise Amplifier (LNA)
4. Low loss Coax cables with N-type Connecters
5. SpectraCyber 1420 MHz Hydrogen Line Spectrometer
6. Computer

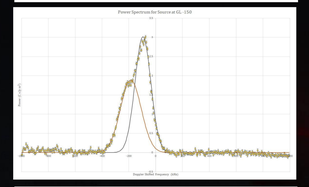


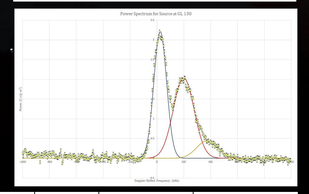


Experiment

1. The 4m SRT is first calibrated to detect the HI line from the galactic plane. Readings from four sources and a calibrator source were recorded by pointing the telescope on the source's coordinates.
2. Then 'SpectraCyber' was used to obtain the power spectrum of the signal corresponding to Doppler shifted frequencies. Origin was used to plot the power density spectrum and fitted with Gaussian.
3. The peak Brightness Temperature (T_b) of the calibrator source was provided which was used to determine a scale factor for the plot and was used subsequently to determine the of the T_b other observed sources.
4. The height, width and position of Gaussian provides information about the strength, column density and velocity of HI line.







Galactic Longitude (degrees)	Peak of Gaussian	Brightness Temperature (K)	Recession Velocity (km/s)
-153 (Calibrator S8)	3.66	72	9.5
-150	3.01	59	10.0
	1.88	37	19.5
130	3.21	45	-2.6
	2.04	40	-21.6
	0.45	9	-39.6

Graphs and Result taken from Group 2 RAWS 2018