SALSA is an ICT based educational tool for Astrophysics students to study structure and dynamics of Milky Way Galaxy

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Overview

1. Primary Discussion
   - SALSA
   - HI Surveys
2. Theory
3. Result of Experiment
4. Importance of this Experiment
5. Conclusion
6. References

Introduction

ICT based astronomy and astrophysics tools have been developed for decades for undergraduate level use including radio telescopes controllable over the Internet at minimal cost. These radio telescopes can effectively be used to study galactic structure and dynamics. This paper presents an observation to study galaxy dynamics and map its spiral structure which was carried out between galactic coordinate longitudes 6° to 225° and latitudes 0° to 35° with two low cost 2.3 meters Haystack model type radio frequency receiving systems called SALSA radio telescopes at Onsala Space Observatory in Sweden which is maintained by Chalmers University of Technology.

SALSA Telescope

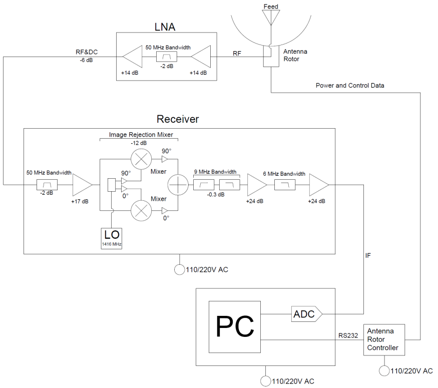
Basic Details of SALSA

SALSA is a part of the European Hands-On Universe project(EU-HOU) [1] designed to bring interactive lessons of astronomy to the classroom. There are two SALSA telescopes with the same specification see Table 1 [2].

Anyone can control these telescopes using Internet browser by log in `https://vale.oso.chalmers.se/salsa/` for free at any time.

Basic Diagram of a SALSA Small Radio Telescope

Figure: Block Diagram of Haystack Small Radio Telescope [3]



SALSA

Table: Specification of SALSA

Parameter	**Value**
Diameter	2.3m
Focal Length	0.9m (f/0.37)
Angular Resolution	7° at 1420MHz
Frequency Range	1420 ± 20MHz
Frequency Resolution	9.375kHz (2.4MHz over 256 Freq. Channels)
Noise Diode Temperature	$\approx$ 100K
System Temperature	$\approx$ 500K
Aperture Efficiency	$\approx$ 50%
Mount	Two-Axis Azimuth/Elevation
Pointing Accuracy	$\approx 0.2^\circ$
Travel Limits	0-90° Vertically, 0-360° Horizontally

Components of SALSA

- A 2.3 meter satellite dish on a fully steerable, motorized azimuth-elevation mount
- A rotor controller to run the motors which steer the telescope
- A feed composed of a helical antenna backed by a cavity
- A super-heterodyne receiver providing 10 MHz bandwidth centered on the 1420.4 MHz (21-cm) hydrogen line
- A low-noise amplifier
- A/D conversion on a dedicated PCI card
- Software on a desktop computer to receive and process data from the telescope and control it

HI Surveys

1. In 1933, Karl Guthe Jansky detected first extraterrestrial radio frequency
2. In 1945 then Van de Hulst predicted 21 cm wavelength emission
3. Detected HI line by Muller and Oort in the same year
4. A preliminary survey was made by Christiansen and Hindman in Australia
5. In Netherlands, Muller and Westerhout
6. All-sky mapping in HI line based on EBHIS and GASS

Within these periods angular resolution has been developed from 30° to 30-μas [4, 5].

Theorem (Hydrogen Line Emission)

- *The frequency of the photon emitted in a transition from the triplet to the singlet state [6]*
  $\nu = \frac{\Delta E}{h} = 1420\,\text{MHz}$
- *The corresponding wavelength is* $c/\nu = 21$ *cm*
- *In a single Hydrogen atom this transition occurs once per* $\approx 10^7$ *years*
- *Enormous amount of Hydrogen in spiral arms of Milky Way galaxy causes pervasive and ubiquitous forms of radiation.*

Hyperfine Splitting of Hydrogen

Figure: 21cm Wave Length Hydrogen Line Emission

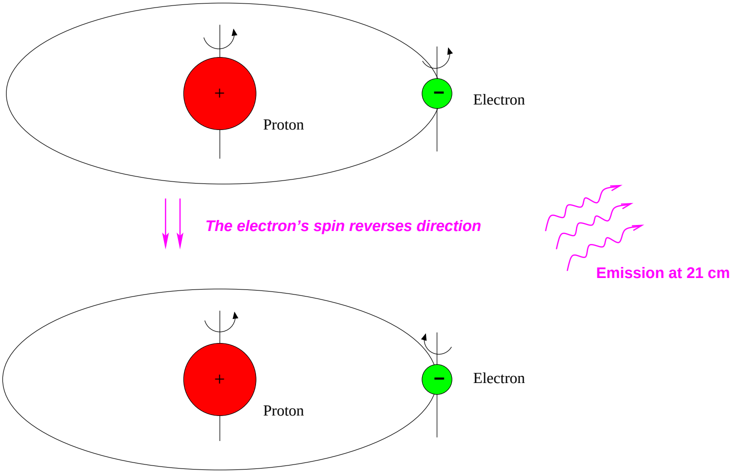
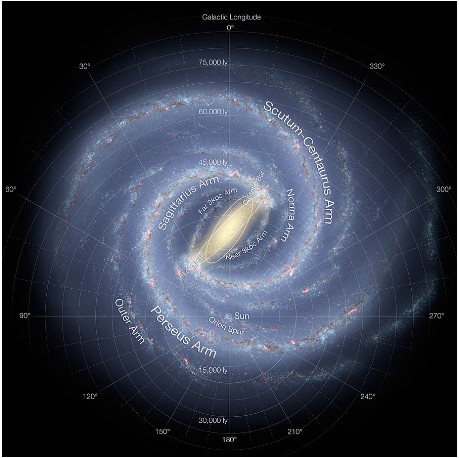
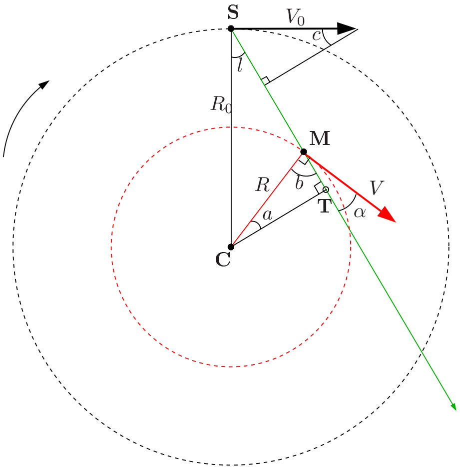


Figure: Milky Way(Credit:NASA/JPL-Caltech/ESO/R. Hurt)



Geometry of Galaxy

Figure: Geometry of the Galaxy. C is Galactic center, S is Sun, M is gas cloud



Theory

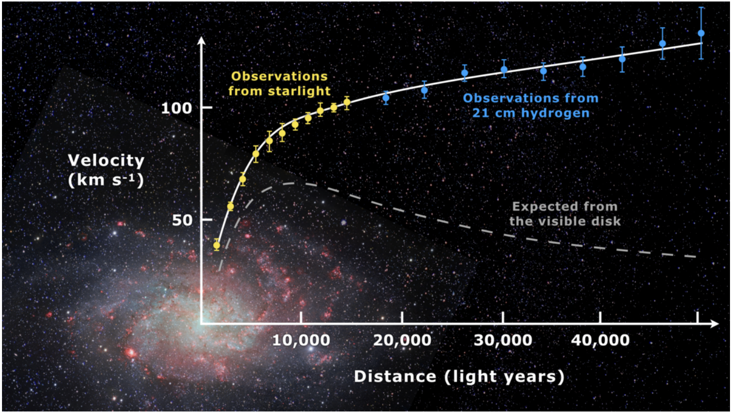
Theorem (Equation of Mapping the Milky Way)

$$\begin{cases} x = r\cos(l - 90^\circ) \\ y = -R_0 + r\sin(l - 90^\circ) \end{cases}$$

This equation is for all galactic longitude l. Here R_0 is distance between Sun and galactic center and r is distance to cloud from the Sun.

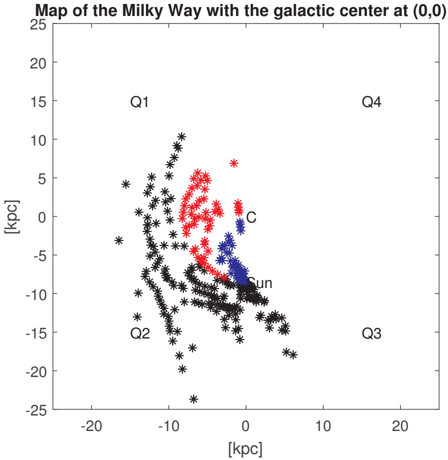
Rotation Curve of a Galaxy

Figure: Rotation curve of spiral galaxy Messier 33



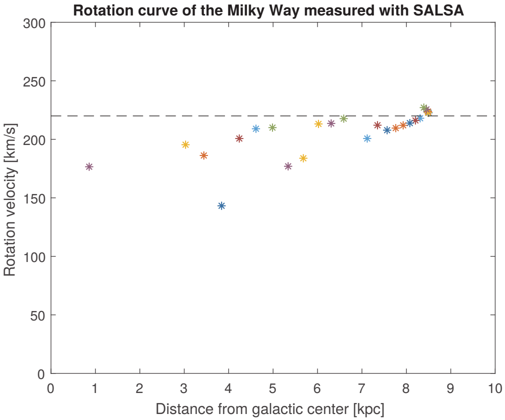
Galactic Mapping

Figure: Mapping of Milky Way at $l = 6^\circ - 225^\circ$ and $b = 0^\circ$



Galactic Rotation Curve

Figure: Rotation Curve of Milky Way at $l = 6^\circ - 225^\circ$ and $b = 0^\circ$



Importance of this Experiment

Astrophysics Education

Astrophysics students who are actually amateur level astronomers can evaluate galaxy dynamics and detect existence of dark matter in our galaxy easily with small radio telescope. This kind of practice can enlighten educators, students and enthusiasts.

Amateur Astronomy and Citizen Science

It will familiarize Observation of planetary radio signals, collecting solar flare data, meteor shower counts, GNSS satellite tracking, x-ray solar bursts detection etc to amateur astronomers and citizen scientists.

STEM Education

STEM students will learn about imaging techniques, signal processing, collecting data and analyze with computer programming and automation.

Conclusion

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