

Measure the Galactic rotation velocity with spectroscopy of 21 cm line using Hary Botte telescope

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GPPU Experimental Point (GEP): 4

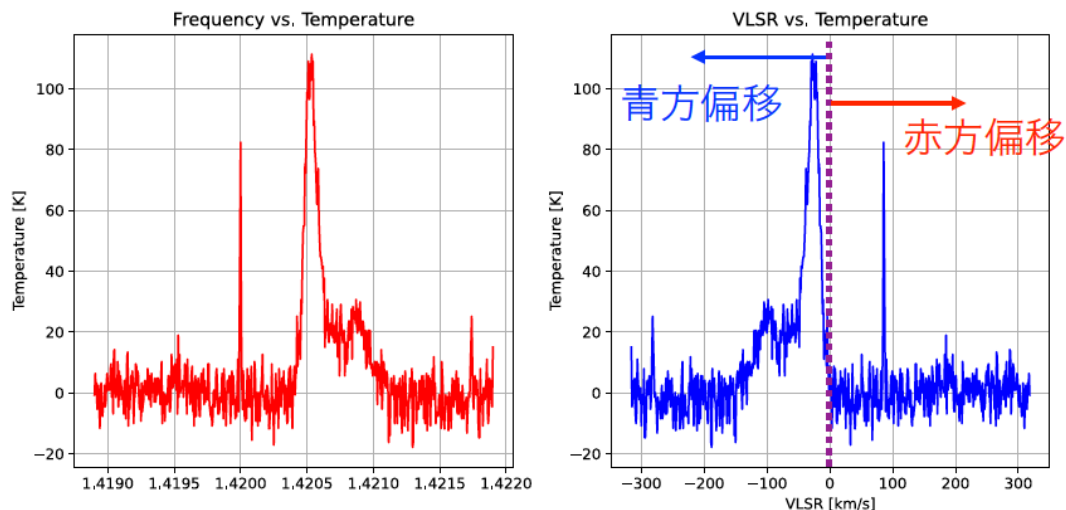
Goal of Study and contents



1. Measure 21 cm emission line (1.4204GHz at rest frame) from neutral hydrogen in the Galactic disk with radio spectroscopic measurement using hand made antenna and extract information of the Galactic rotation from the line features. Simultaneously, try to measure spectrum feature of the CMB (its shape and possibly temperature).

2. Experience physical optics simulation by simulating the beam pattern of the antenna which we use in the measurement experiment with simulator CST.

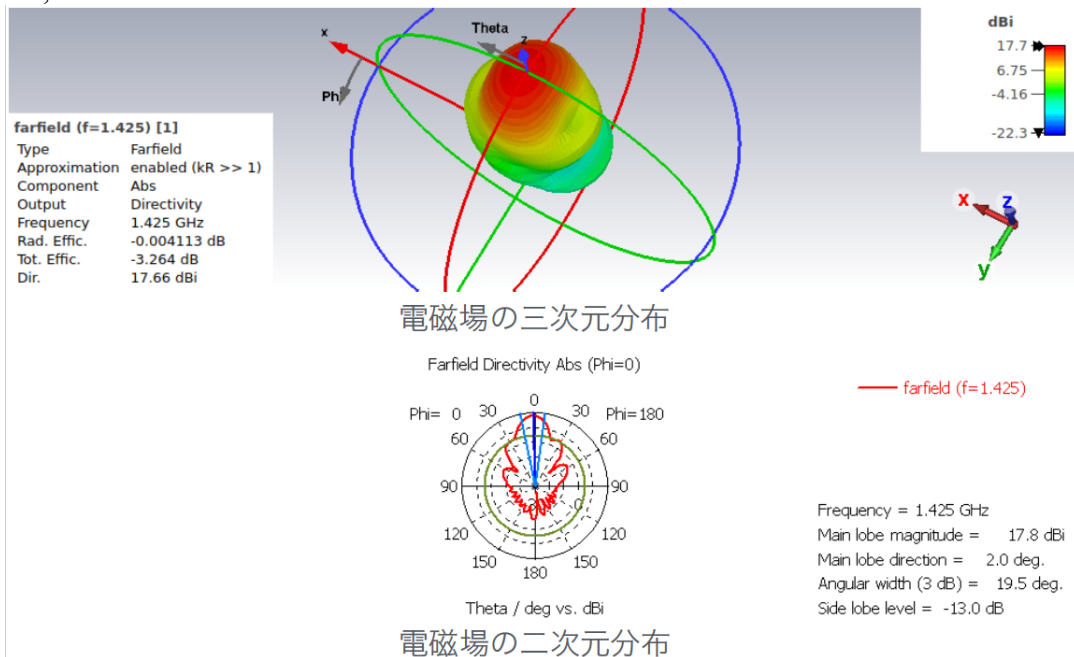
Photo is the measurement system.



The bottom figure shows the example of the obtained results in this course. The pointing direction is the Cygnus constellation. We can see that the line is blue shifted. It shows that the Galactic arm in the direction of the Cygnus is move forward relative to us. Appearance of the second peak in the spectrum shows that the line of sight toward the Cygnus passes through two individual Galactic arms. From the line width, we are able to extract the information of the velocity dispersion of the random motion of the Hydrogen cloud in each arm. From the intensity, we are able to extract the column density of the neutral hydrogen toward the line of sight.

The upper panel shows the obtained spectrum when the antenna pointed the Lynx. In this

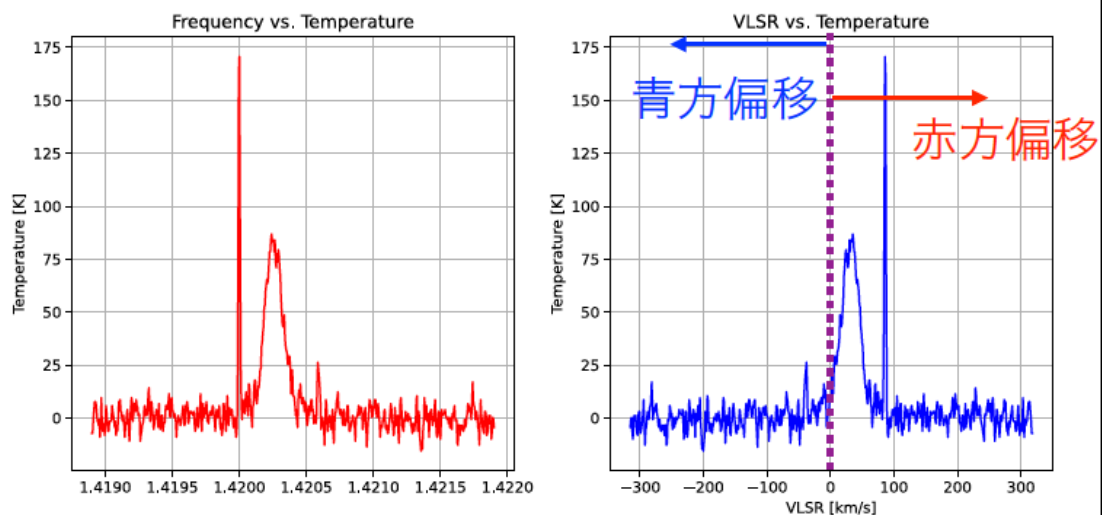
case, the line is redshifted.

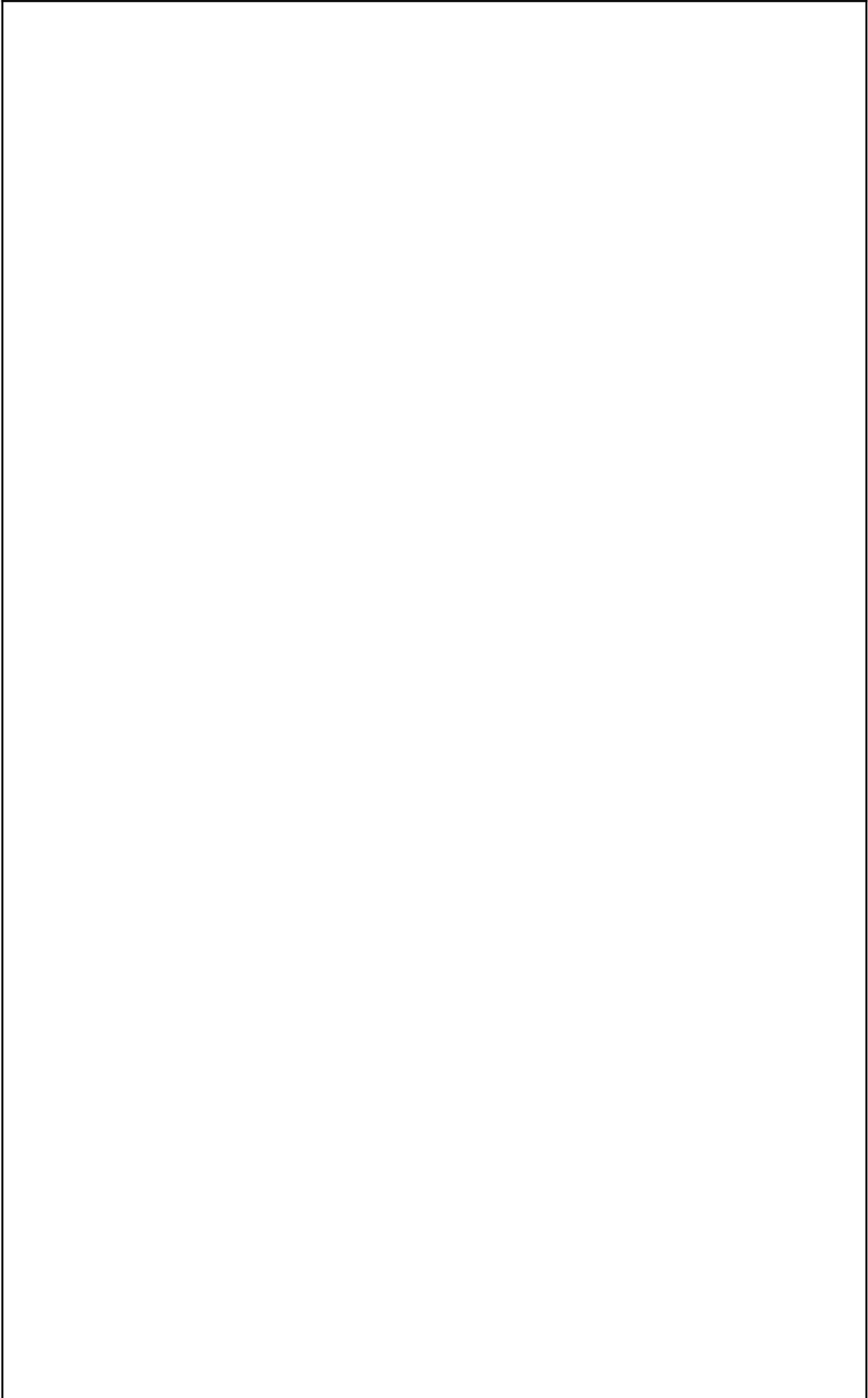


By pointing many direction, you can study the nature of the Galactic rotation.

Upper panel shows the beam pattern simulation results with the CST. By changing the set up parameters, we can feel how the beam pattern responds to each set up parameter of the antenna.

Participants must take a lecture before this September. Anytime before end of the September is available. However, any delay of completing the lecture is not allowed.





Textbook and References

- [1] <https://physicsopenlab.org/2020/09/08/milky-way-structure-detected-with-the-21-cm-neutral-hydrogen-emission/>

Progress Schedule

- ◇ Day 1
Make a strategy of the observations.
- ◇ Day 2
Perform radio spectroscopy toward one direction of the sky.
- ◇ Day 3
Perform radio spectroscopy toward another direction of the sky.
- ◇ Day 4
Beam pattern simulation with physical optics simulator CST.

Other Details

Course Period	2026
Place	Complex C S512 & H26 Physics research building 217 and roof.
Number of Students	1-2 is appropriate but basically no restriction. If many, negotiable.
Evaluation method	Quality of the report.

In Addition