PRACTICAL SESSION FOR INSTRUMENTATION
MASTER 2 ASEP & TSI

Objective

The aim of this practical work is to handle a radio telescope and learn about antenna calibration and characterization procedures.

Instrument

The practical work is based entirely on the use of the radio telescope located on the roof of the Observatoire Midi-Pyrénées (OMP). This is a 3m diameter steerable parabolic dish equipped with a 21cm wavelength receiver (frontend) and acquisition electronics (backend) capable of producing 1.2 MHz band spectra.

Procedure

Students work in pairs to take measurements on the control computer located under the antenna, in room D022 on the IRAP Belin site (OMP). Each pair is assigned one of the 5 subjects listed below. Observing time is around 45 minutes. The students are then asked to carry out an analysis, possibly including other archive data. The aim is not to apply a pre-established protocol, but rather to carry out a research project with a few references. All in all, the project is estimated to take around 5 hours to complete. Sample observation and analysis scripts will be provided.

1. Measuring antenna lobe and pointing error

- Recall what an antenna beam pattern (or lobe, or gain) is and what its shape is in the case of a circular aperture.
- Create an observation script to make a map centered on the Sun
- Observe the Sun with this script
- Write a Python program to produce a map from the data obtained.
- Write a Python program to measure the lobe's parameters (width and pointing error), assuming it has a Gaussian shape.
- Compare the result with the expected theoretical values

2. Pointing modeling and error correction

- Write an observation script for a series of maps centered on the Sun.
- Observe the Sun with this script
- Write a python program to plot the pointing error as a function of time (scripts for producing a map and measuring pointing errors will be provided).
- Use data obtained over a full day of Sun monitoring (archives) to plot variations in pointing errors over the course of the day.
- Find an expression for the change in celestial coordinates (alt, az) when the mast supporting the antenna is tilted.
- Use a python program to simulate pointing errors on the Sun over the course of a day for a mast tilt of a few degrees
- Write a python program to adjust a mast tilt model to the Sun's observations over the course of a day.

3. Calibration of antenna efficiency and sensitivity

- Recall the definition of an antenna temperature and propose a calibration procedure.
- Recall the Sun's emission processes at 1420MHz. What is the shape of the expected

spectrum? Is the flux constant?
- Make a map of the sky centered on the Sun to obtain a measurement of its flux in arbitrary units, and compare it with the flux measured by other radio telescopes (https://www.sws.bom.gov.au/World_Data_Centre/1/10).
- Measure telescope sensitivity (noise level obtained after one second of integration)
- How long does integration take to detect the Crab Nebula?

4. Measure sky noise as a function of elevation

- Write a script to scan the sky in elevation.
- Write a python program to analyze the data and plot the noise level as a function of elevation and air mass.
- Estimate the value of the system temperature
- Discuss the feasibility of measuring the cosmological background.

5. Estimate of hydrogen mass in the Galaxy from HI line intensity

- Calibrate antenna efficiency on the Sun
- Point a direction in the Milky Way disc and interpret the spectrum.
- Convert total line intensity into hydrogen column density
- Estimate the mass of hydrogen in the Galaxy.