URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Radiometer Calibration of the MIST Global 21-cm Experiment

Raul A. Monsalve[(1)]
(1) Facultad de Ingeniería, Universidad Católica de la Santísima Concepción, Alonso de Ribera 2850, Concepción, Chile

The Mapper of the IGM Spin Temperature (MIST) is a new radio cosmology experiment whose objective is to measure the sky-averaged, or global, 21-cm signal emitted by neutral hydrogen gas in the intergalactic medium (IGM) during the dark ages, cosmic dawn, and epoch of reionization. The MIST team includes collaborators from Universidad Católica de la Santísima Concepción in Chile, McGill University in Canada, and NRAO in the US. The MIST instrument design corresponds to a single-antenna, absolutely-calibrated total-power radiometer, which will measure the sky spectrum in the frequency range 40-200 MHz as the sky drifts above the antenna. MIST will be deployed at remote locations of the Earth, including the Atacama Desert in Northern Chile and the Canadian Arctic, in order to minimize the effect on the sky measurements of human-generated radio-frequency interference.

In this talk I will describe the absolute calibration of the MIST total-power radiometer. The MIST calibration approach consists of determining the gain, noise offset, and noise parameters of the instrument's analog chain using field and laboratory data, and then use these parameters to calibrate the sky data. This technique was introduced in the context of 21-cm cosmology in [1]. We first determine initial estimates for the gain and noise offset from field measurements of two noise references connected to the input of the instrument: an ambient load and an active noise source. These field measurements are conducted in parallel to the sky measurements with the antenna. We determine absolute corrections to the initial estimates for the gain and noise offset, as well as the noise parameters of the instrument, from laboratory measurements of absolute calibrators. These calibrators correspond to passive devices that have different physical temperatures, noise temperatures, and complex reflection coefficients. The information provided by these laboratory measurements enables us to determine the absolute calibration parameters. Because the 21-cm signal pursued by MIST has a maximum expected brightness temperature of ≈ 200 mK, our target accuracy and precision for the radiometer calibration is 10 mK or better.

My talk will describe in detail the laboratory measurements of the absolute calibrators with the MIST instrument and the determination of the radiometer parameters. I will introduce the calibrators, present the latest data, and describe step-by-step the algorithm used to estimate the parameters. I will also discuss how we verify the accuracy of our radiometer calibration, which involves measuring and calibrating the data from additional devices of known noise temperatures connected to the input of the instrument. I will discuss the accuracy and precision achieved in our latest tests and the steps being taken to significantly improve the performance.

References

[1] A. E. E. Rogers & J. D. Bowman, "Absolute calibration of a wideband antenna and spectrometer for accurate sky noise temperature measurements," *Radio Science*, **47**, July 2012, RS0K06, doi: 10.1029/2011RS004962.