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Calibration of the Netherlands-China Low Frequency Explorer

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Extended Abstract

The Netherlands China Low frequency Explorer (NCLE) instrument is a scientific payload hosted by the Chinese Chang'e 4 orbiter. The satellite's main mission is to serve as a relay between the Earth and a lander on the far side of the moon and will be placed in an orbit around the Earth-moon L2 point. The NCLE is a low-frequency radio experiment that serves as a pathfinder for a future low-frequency space-based or moon-based radio interferometer. Its frequency range will be 80 kHz up to 80 MHz.

The NCLE instrument has three 5-m long (almost) orthogonal monopole antennas, mounted on one of the spacecraft walls, to receive signals in all polarizations. The antennas are connected differentially as dipoles to LNAs for a first amplification, followed by analog stages with filtering to limit the bandwidth, and with additional amplification. The analog signals are fed into high-resolution ADCs, which convert the analog signals into digital ones. An FPGA-based digital receiver takes care of a first processing step, after which the data is buffered, before sending it to the Earth. On Earth a more detailed analysis of the measured data will be made.

The environment in which the NCLE instrument will be operating is harsh; there are large variations in temperature and the electronics will age relatively quickly due to damage by ionizing cosmic radiation. The environment will have an impact on the gain and phase stability of the three receiver chains. For reliable analysis of the measured data it is necessary to monitor the stability of the receiver chains, i.e. to have a relative calibration of the three receiver chains with respect to each other. In order to compare the measured data with results from other radio telescopes, the instrument needs to be calibrated in an absolute sense.

The absolute calibration of the NCLE instrument will be mainly based on the use of galactic sources, such as strong point sources and a global sky model. Variable galactic sources and communication transmitters are considered as well. The use of goniopolarimetric techniques on strong Solar system sources is considered for the instrumental polarization calibration.

For the relative calibration, a pulse train will be injected into the analog signal path just before the LNA. This pulse train can be switched on and off for each receiver chain independently. A copy of the pulse train is injected directly to one of the ADC channels for reference. Obtaining the complex transfer function, i.e. the gain and phase of the receiver channel, is a relatively simple mathematical operation.

In this presentation, the calibration approach of the NCLE instrument will be explained in detail, together with simulations and measurements from prototypes.

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