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CALIBRATION APPROACH OF THE OLFAR SPACE BASED RADIO TELESCOPE

Abstract

In recent years, science drivers have emerged for radio astronomy in the frequency range between 0.3 and 30 MHz. Due to strong man-made radio frequency interference (RFI) and opacity and scintillation in the ionosphere, this is not possible from Earth. For this reason the Orbiting Low-Frequency Antennas for Radio Astronomy (OLFAR) project aims to develop a space-based radio telescope, consisting of 50 or more nano-satellites in a location far away from Earth. These satellites will be flying in a swarm approximately 100 km in diameter to synthesize a large radio aperture. The observational antenna systems will need to be calibrated, to be able to extract the astronomical signals from the detected signal. This detected signal can potentially be corrupted by sources internal to the satellite, such as gain instability of the low-noise amplifiers and internally generated RFI, or by external sources, such as obstruction by the solar panels, misalignment of the antennas and errors in the attitude determination, or from sources outside of the satellite swarm, such as man-made interference from Earth. Several factors however make the calibration of OLFAR a unique challenge. Due in part to the limited size of the nano-satellites, the current design for the observational antennas is simply a set of three perpendicularly deployable dipoles, each consisting of two connected wire antennas extending from opposite sides of the satellite body. Therefore the antenna beam size will be unprecedented in modern radio astronomy, especially since there will be no Earth to obscure half the celestial sphere. Furthermore, one pair of opposing wire antennas will not be in line with each other, skewing the antenna pattern. And, in contrast to the others which are connected physically, this same pair will also have separate RF front ends that will be connected digitally, which further affects its calibration. Another factor is that satellites in a swarm will have random relative positions in three dimensions. In addition, the on-board processing capacity is limited, due to the limited available power and small size of the nano-satellites. This paper will give an overview of the challenges and expected errors in the detected signal, and propose an approach to mitigate the errors and perform calibration. It will be outlined which parts of the calibration must be done by the satellite (e.g. measuring the noise factor of the receiver by using an internal noise source), and which parts can be done on Earth in post-processing.