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Designing antennas for large N Aperture Arrays: the SKA and HERA cases

E. De Lera Acedo[(1)], N. Fagnoni[(1)], H. Pienaar[(1)]
(on behalf of the *SKA LFAA Antenna and LNA Work Package* and the *HERA analogue team*)
(1) Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom

The Square Kilometre Array (SKA) [1] and the Hydrogen Epoch of Re-ionization Array (HERA) [2] are two of the most prominent, technically advanced large N aperture arrays as well as ambitious radio astronomy projects in development today. These two projects will count with a large number of aperture antennas (512 stations with 256 antenna elements each in the case of the SKA1-LOW instrument and ~350 14-m dish antennas in the case of HERA). SKA1-LOW (the low-frequency instrument of SKA) and HERA have several common aspects as well as differences in both their scientific aims and its design goals and requirements, and so do their array antennas.

The SKA represents the largest and most powerful radio telescope at meter and centimeter wavelengths that has ever existed. Its extraordinary sensitivity and flexible design will allow SKA tackle a large number of key scientific projects. The SKA1-low instrument (50-350 MHz) will populate the semi-deserted areas of Western Australia and will carry out detailed studies of the very early Universe, the birth of the first starts and its evolution. Furthermore, the SKA1-LOW will also research on Pulsars and other transients as well as a series of other exciting scientific cases. SKA's all digital approach with more than 131,000 antenna elements electronically scanning the array in every direction calling for an array antenna design that can provide the demanding requirements of SKA: sensitivity, field of view, spectral smoothness, polarization purity, etc in an ultra-wide frequency band (7:1). Aspects such as the matching the antennas to the low noise amplifiers are key for both achieving superb sensitivity as well as spectral smoothness. The mutual coupling in the stations is also a key component in the design and especially the calibration of these antennas. Furthermore, the SKA numbers call for a robust, low-cost design to be produced in high volume.

HERA on the other hand is a focused experiment targeting the detection of the power spectrum signature signal from the Epoch of Re-ionization. It is also a wideband instrument (50-250 MHz) that will use the so-called Delay Spectrum technique for the analysis of the received signal. This technique calls for an antenna design with a time-domain transfer function as close to the delta function as possible (a truly wideband design). With a much less demanding cost budget and narrower field of view, HERA is currently being installed in the Karoo radio reserve, South Africa.

In this presentation, we will give a summary of the design challenges and up to date design process for the antennas of this two telescopes. This design has been led by researchers from the Cavendish Laboratory, University of Cambridge in collaboration with Cambridge Consultants Ltd. The antenna design work is part of a design consortium in the case of SKA (The Aperture Array Design Consortium) and a design team (the analogue team) in the case of HERA. The SKA antenna is a log-periodic antenna currently in its 4th iteration (SKALA4, see Fig.1) after a selection process in the summer of 2017 and the HERA feed is a Vivaldi type antenna (see Fig. 2). In the presentation, we will explain the latest updates on both designs.

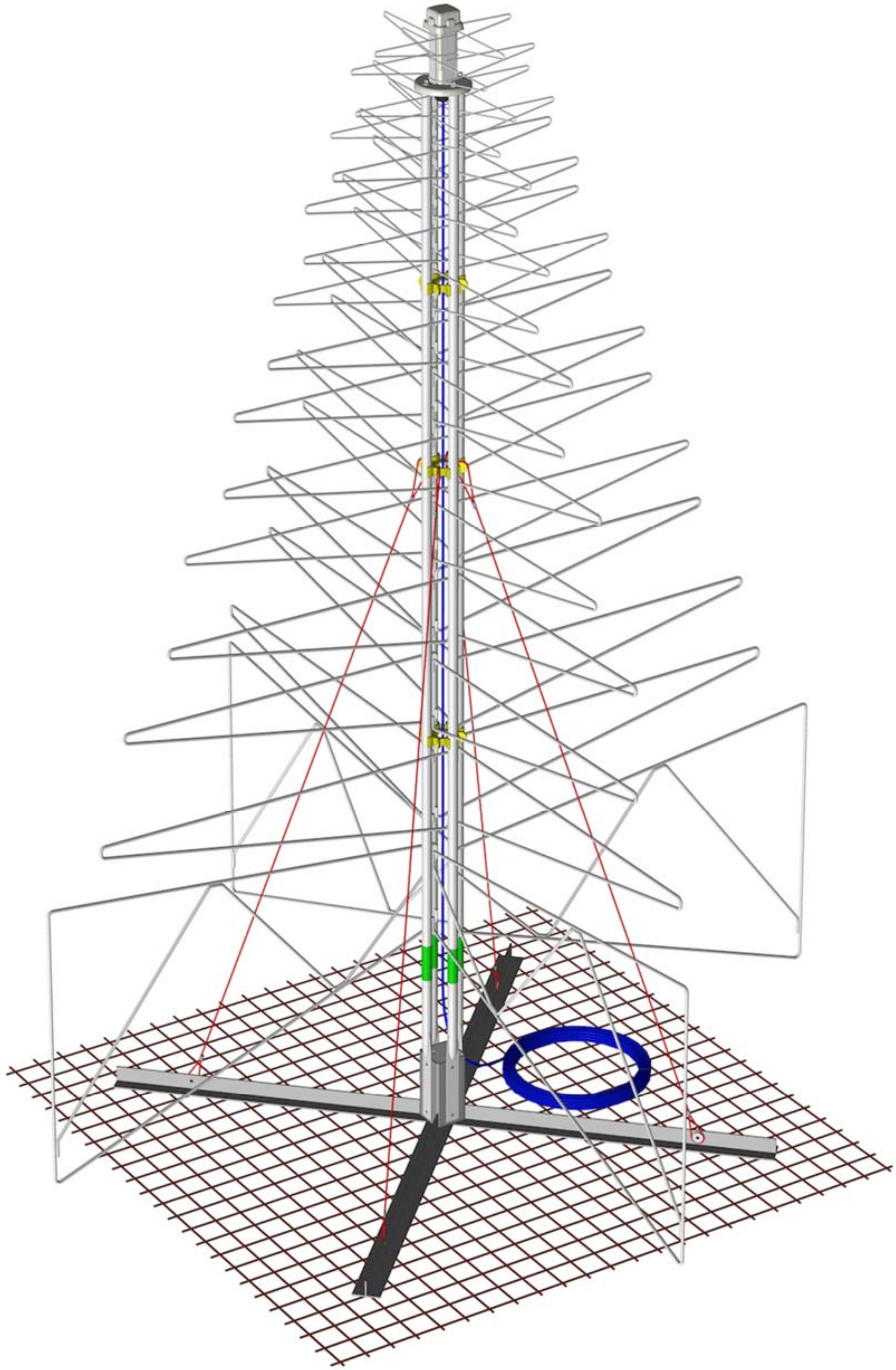

Figure 1. SKALA4 antenna

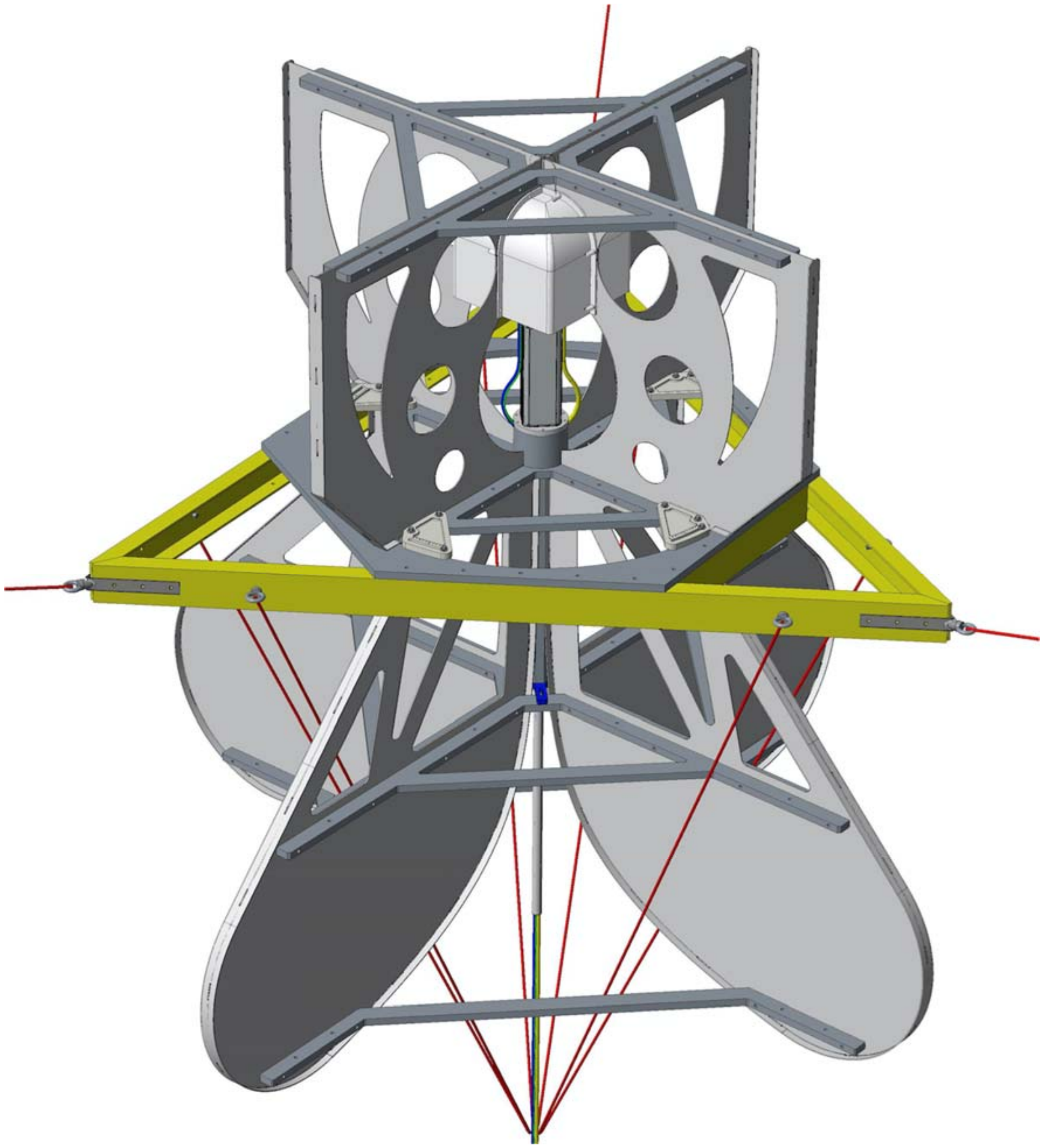

Figure 2. HERA V-feed antenna

1. The Square Kilometre Array, www.skatelescope.org

2. The Hydrogen Epoch of Re-ionization Array, reionization.org