Efficient Numerical Analysis of Prototype Antennas for the Square Kilometre Array (SKA) Using the Characteristic Basis Function Method (CBFM)

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The international radio astronomy community is currently making detailed plans for the development of a new radio telescope–the Square Kilometre Array (SKA). ASTRON is one of the institutes that are involved in analyzing and designing demonstrators for large phased arrays and Focal Plane Arrays for the SKA. Most of these utilize very large antenna arrays and they can be designed, to first-order, by using the infinite array approach. However, the infinite array approach is not accurate for a practical design of the FPAs, which require a non-uniform and complex weighting scheme. Moreover the finiteness of FPAs gives rise to truncation effects, especially at low frequencies and off-axis beams. Also, for some of our phased array concepts we need to distinguish between the periodicity at element level and the periodicity at tile level (multi-scale problems), and the use of a dedicated technique is preferred for accurate and efficient modeling of these effects.

The Characteristic Basis Function Method (CBFM), which is an efficient numerical technique for solving large multi-scale problems, is employed in this work to address is a very efficient numerical technique for solving large multi-scale problems. This method essentially decomposes the computational domain into many smaller sub-domains, each of which can be easily handled on a single processor, hence, it is highly suitable for implementation on large supercomputers such as the LOFAR BlueGene/L located at the university of Groningen. The paper will present numerical results that show that the MoM matrix size can be reduced by factors of 50 or more (>90 in some cases), and the solve-time by an order of magnitude or higher, without compromising the accuracy of the results. The CPU times for the conventional MoM and CBFM running on PCs will be included to show how these times scale with the number of unknowns, which can reach up to several tens of thousands.

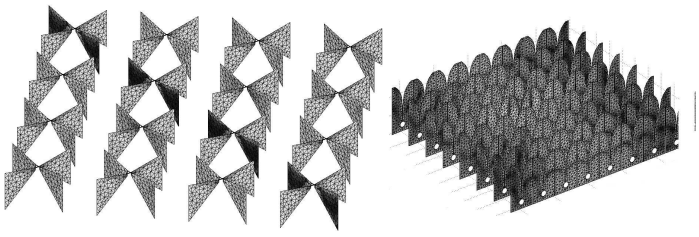

Figure 1: The LOFAR Highband Antenna Array (HBA); an SKA demonstrator for low frequencies, and an 8x8 Vivaldi element Array; an SKA demonstrator for mid-band frequencies.