The Characteristic Basis Function Method (CBFM) – An Alternative to FMM for a class of Antenna and Scattering Problems

Raj Mittra and V.V.S. Prakash

319 Electrical Engineering East,
The Pennsylvania State University, University Park, PA 16802-2705
E.mail: Mittra@engr.psu.edu

The Fast Multipole Method (FMM) and its multilevel variants are very elegant and well-established approaches to fast solution of RCS problems formulated via the Method of Moments (MoM), and the FMM is clearly the chief protagonist in the CEM-solver world today, for attacking the EM scattering problems involving large bodies. The purpose of this paper is to present an alternate approach (CBFM), which is designed to complement the FMM in a whole host of situations. These include the modeling of large antennas and arrays, and the RCS computation of large objects that one might want to handle by using the MoM, FEM, or FDTD, depending upon the nature of the problem (note that the CBFM is not limited to MoM formulation alone).

The core concept in CBFM is the reduction of Degrees of Freedom (DOFs) with which to describe a problem. This reduction is realized by solving a number of sub-problems used to generate what are defined as the *primary* and *secondary* basis functions – which are adequate for many problems, though higher-order functions can be readily added on *as-needed* basis. The reduced matrix in MoM or FEM is typically several orders of magnitude smaller than the size of the original matrix. The principal advantage of the reduction process is that it obviates the need for iterative solution in many practical problems of interest, as for instance a large finite phased array antenna, or FSS radome problem comprising of several thousands of elements, which are not amenable to the analysis by using the conventional approaches, including the FMM.

The presentation will include numerous examples of the application of the CBFM to a wide variety of problems; (a) Two-layer Fractal antenna, which takes several hours to simulate using a commercial MoM code (b) a large phased array with more than 2,500 elements simulated by FDTD; (c) RCS of typical objects at multiple frequencies and look angles by using RWG/MoM code in conjunction with CBFM; (d) a phased array covered by an FSS radome whose periods are dissimilar; (e) modeling of a very large waveguide phased array, whose geometry is quasi-periodic.

We will also present a novel approach for generating the MoM matrix elements, based on their Characteristic Basis Function representation that requires only a few (<10) DOFs to represent the entire impedance matrix of the system.

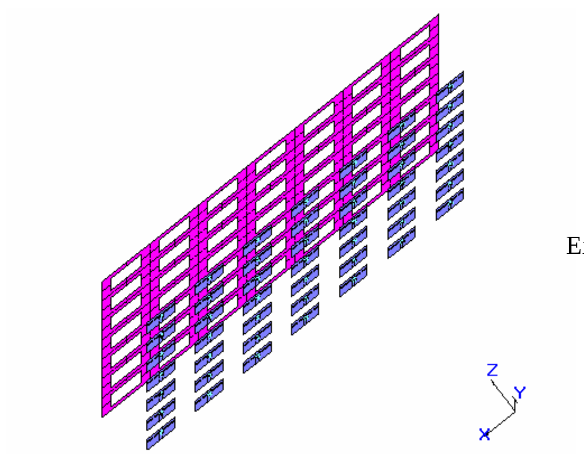

Fig.1. Microstrip patch array with radome cover.

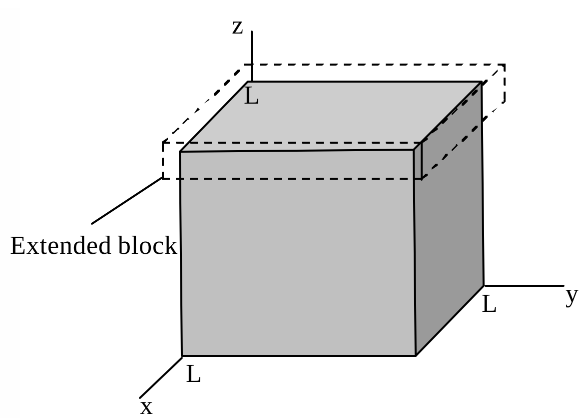

Fig.2. Geometry of metallic cube. Each face of the cube is treated as one block with six CBFs.