CHARACTERISTIC BASIS FUNCCTION METHOD—A NOVEL APPROACH TO SOLVING LARGE PROBLEMS INVOLVING MICROWAVE ANTENNAS, ARRAYS AND RADAR SCATTERERS

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Abstract

Despite a recent spectacular increase in our capability to numerically model, simulate the performances, and design complex electromagnetic systems, we often encounter problems that are so large (see Figs. 1 through 6 for examples) as to be beyond the reach of available computational resources to tackle them using conventional CEM techniques. The purpose of this talk is to introduce a recently-developed approach, called the Characteristic Basis Function Method (CBFM) for handling such problems that are often encountered in practice. Examples include large antennas and arrays, dielectric or Frequency Selective Surface (FSS) radomes, radar targets and EMI/EMC problems that are not amenable to analysis via the GTD, PTD or other asymptotic methods commonly used for large problems. This is because the asymptotic techniques are often limited in their application to PEC structures, or those whose surfaces can be described in terms of approximate reflection coefficients. Many practical CEM modeling problems of interest do not fall in this category and, hence, the search for numerically efficient techniques to solve large problems involving complex structures continues unabated.

In this talk we will begin by briefly reviewing the progress made in enhancing the available CEM techniques, *viz*., the Method of Moments (MoM), Finite Element Method (FEM), and the Finite Difference Time Domain (FDTD) or its variants. Of these the MoM is best suited for PEC structures, or those with homogeneous dielectric coatings, whereas the finite methods can handle arbitrary objects, comprising of both PECs and inhomogeneous dielectrics, including metamaterials—albeit at a computational cost which is higher than that of the MoM for PEC objects. Since the MoM generates a dense matrix, typically the number of DOFs (degrees of freedom) that it can handle is usually smaller than that can be dealt with using the FEM, or the FDTD. Great strides have recently been made in enlarging the scope of MoM via the use of the Fast Multipole Method (FMM), which has made it feasible for us to solve problems that require the handling of 10^6 DOFs, or even higher. The FDTD can routinely handle upward of 10^9 DOFs on a moderate size computing platform, but it requires a discretization, which is 2 to 3 times finer than that employed in the MoM. However, we explain, via illustrative examples, why these methods are still limited in their ability to solve large complex problems of practical interest that we frequently encounter.

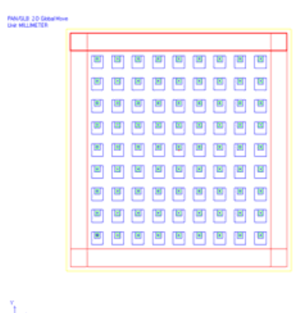

Figure 1. Probe-fed microstrip Patch Array–The number of elements can be several thousands.

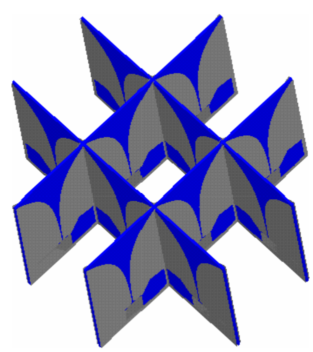

Figure 2. Dual-polarized Vivaldi array. This is a complex phased array element not amenable to convenient analysis using MoM.

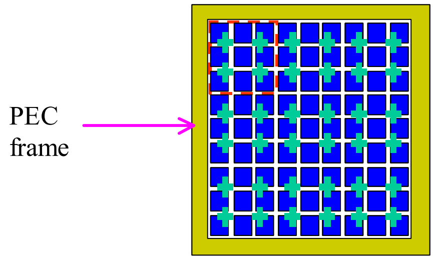

Figure 3. Top view of a microstrip Patch Array covered a FSS radome with cross–shaped elements. Note: The two periods (array and FSS) are not the same. Again, both the array and the radome are typically large.

*Figure 4. A conformal array of circular patch antennas mounted on the surface of a dielectric sphere with a perfectly conducting core. Both the number of elements and the radius of curvature **of the** surface can be large.*

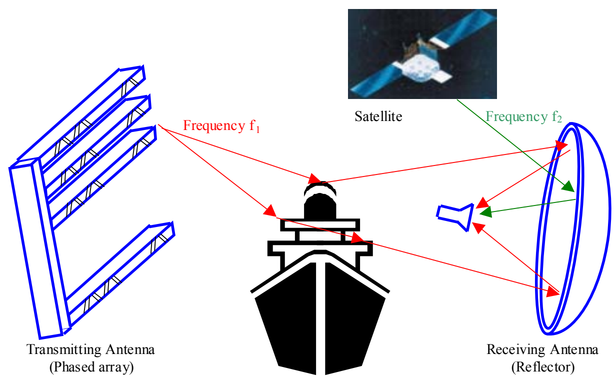

Figure 5. Coupling problem between a large phased array antenna and a reflector antenna, operating in the topside environment. The dimensions of the platform can be thousands of wavelengths.

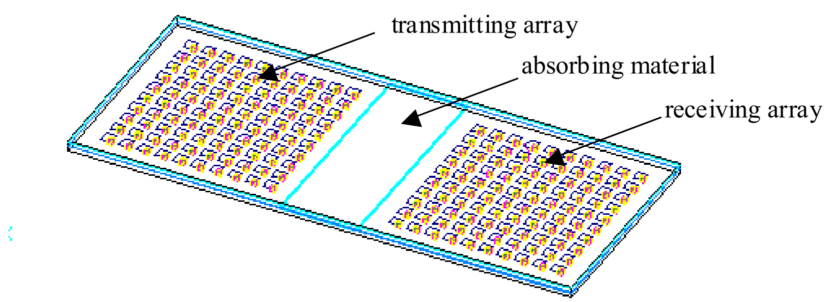

Figure 6. Problem of coupling two array antennas with absorbing material inserted between them. Both the transmit and receive arrays can be large and may be designed to operate at different frequencies.

The talk will explain how this diverse array of problems, and several other antenna, RCS and EMI/EMC problems can be handled by using the CBFM that adds certain modules to the legacy MoM or FDTD codes and makes extensive use of LINUX clusters to solve large problems.