Hybridizing Asymptotic and Numerically Rigorous Techniques for Solving Electromagnetic Scattering Problems using the Characteristics Basis Functions (CBFs)

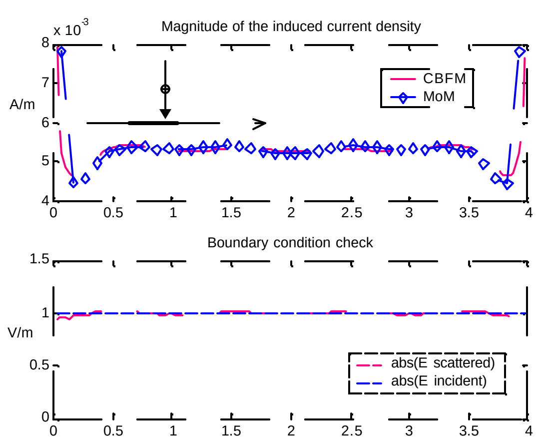
G. Tiberi, A. Monorchio, G. Manara
Dept. of Information Eng.
University of Pisa, Italy

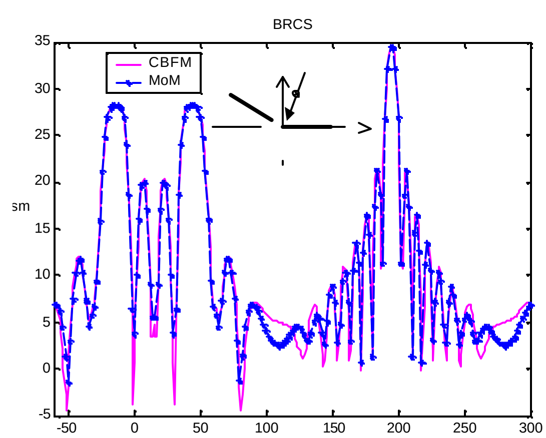
R. Mittra
EMC Lab
Penn State University, USA

Abstract

The problem of electromagnetic scattering from large bodies is often addressed by using asymptotic methods such as the GTD, because the size of the problem makes the numerically rigorous techniques either impractical or uneconomical to use. To render the problem manageable, one sometimes employs a numerically rigorous method, e.g., the Method of Moments with subdomain basis functions, on a part of the body to improve the accuracy of the solution, while using an asymptotic scheme—such as Physical Optics (PO)—elsewhere. This type of hybridization approach, though attractive in principle, is often found to be fraught with pitfalls when applied in practice, not only because it is difficult to find a systematic approach by which the two methods can be dovetailed, but also because it often leads to ill-conditioned matrices.

In this paper we describe a novel approach based on the use of the Characteristic Basis Functions (CBFs) [V.V.S. Prakash and Raj Mittra, Microwave and Optical Technology Letters, March 2003], which have the same features as the asymptotic solutions, but are utilized in a Galerkin type of numerically rigorous matrix method to satisfy the boundary condition on the scatterer. We assume that the scatterer can be represented as a faceted structure, and we introduce three types of *primary* CBFs to be used to represent the induced currents on the facets. The first type of the primary CBFs, have characteristics similar to the Physical Optics currents; but, unlike the PO currents, they exist both in the lit and shadow regions. The other two basis functions are similar to fringe currents, and they are either free-edge or corner-fringe types, depending upon the connectivity of the facet. The secondary basis functions are derived next from the primary ones by using the technique given in the reference above. The above basis functions are subsequently used to construct a matrix equation by imposing the boundary condition on the scatterer in a numerically rigorous manner — a feature unavailable in the asymptotic methods. Another useful feature of the CBFs is that, if necessary, they can be readily hybridized with RWG bases for complex objects. Two representative numerical examples involving a 4λ flat plate (left figures) and a 12λ dihedral (right figure) are given below to illustrate the application of the method.





Note: We point out that the slight difference in RCS in the vicinity of the grazing angles stems from the inability of the MoM to satisfy the edge condition accurately, which the CBFs do satisfy rigorously. The difference in the edge behavior is evident from the top left figure, which plots the two current distributions. The number of CBFs are less than 10 in both of these examples.