

An Efficient Hybrid MoM-T-Matrix-UTD Method for Modeling Electromagnetic Problems

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The electromagnetic behavior of arbitrarily shaped and sized objects, containing both electrically small and large structures, can be analyzed efficiently using hybrid techniques that combine the exact full-wave and asymptotic methods. One such approach is the hybrid method of moments (MoM) and uniform theory of diffraction (UTD), which offers a methodology for capturing the coupling of fields scattered by electrically large objects treated by UTD and subwavelength structures modeled by MoM. In this method, multiple ray traces must be performed for every pair of source and test triangles (mesh elements) to capture the complete electromagnetic interactions between the scattering objects. The computation time required for ray tracing becomes a bottleneck when the number of MoM unknowns is large. To solve this problem, a hybrid multilevel fast multipole method (MLFMM) and UTD approach was proposed by A. Tzoulis, *et al.* (A. Tzoulis, and T. F. Eibert, "A Hybrid FEBI-MLFMM-UTD Method for Numerical Solutions of Electromagnetic Problems Including Arbitrarily Shaped and Electrically Large Objects," *IEEE Trans. Antennas Propag.*, **53**(10), 2005) where ray tracing is required to be performed only between the centers of the source and receiving MLFMM groups. Although this method reduces the number of ray traces, it still requires one to keep track of multiple ray paths to accurately evaluate the total scattered fields.

In this work, we present the concept of describing fields scattered by a MoM object using an equivalent T-matrix formulation. This information is integrated with the ray tracing algorithm to expedite the field computation. The scattered fields are represented as a linear combination of vector spherical sources located at the center of a sphere circumscribing the MoM object. The minimum number of spherical sources required to accurately compute the fields depends only on the radius of the circumscribing sphere, and is traditionally much smaller than the number of MoM unknowns. This significantly reduces the computation time required to perform the ray tracing process. Furthermore, since the spherical wave sources are assumed to be located at the center of the sphere, only a few ray traces are required to update the T-matrix coefficients. As an initial example, a metallic plate with dimensions $10\lambda \times 5\lambda$ was excited by a y-polarized plane wave traveling at oblique incident with $\theta = 20^\circ$, $\phi = 270^\circ$, $|\mathbf{E}_i| = 1$ V/m, and $f = 4$ GHz as shown in Fig. 1. The observation points were placed at a distance of $r = 64\lambda$ for $\phi = 90^\circ$ and $0 \leq \theta \leq 180^\circ$. The plane wave was presented as a set of vector spherical sources, and a comparison of the total electric field at the observation points is shown in Fig. 1, where excellent agreement with the reference solution can be observed. Additionally, results involving scattering in the presence of a MoM object will be presented at the conference.

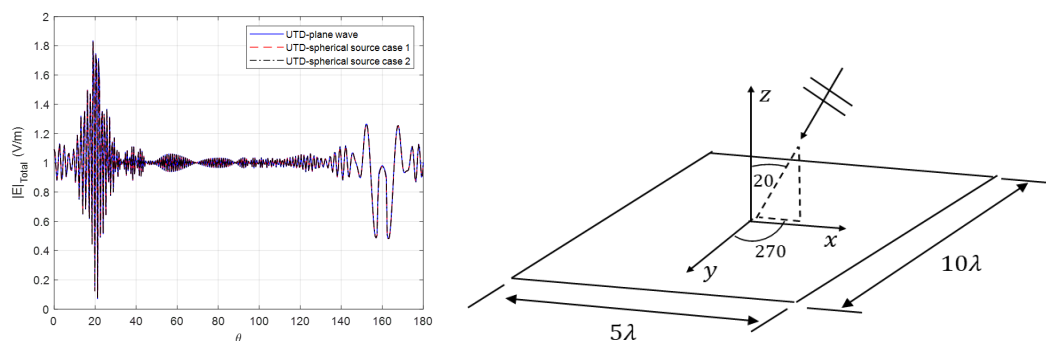


Figure 1. A comparison of total electric field obtained by spherical sources (left) and plane wave illumination of a metallic plate (right).