2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Fast Direct Method of Moments Solution of Surface-Volume-Surface Integral Equation with H-Matrices

Reza Gholami(1), Jamiu Mojolagbe (1), Anton Menshov(2), Farhad Sheikh Hosseini Lori(1), and Vladimir Okhmatovski* (1)
(1) University of Manitoba, Winnipeg, R3T5V6, Canada, e-mail: vladimir.okhmatovski@umanitoba.ca
(2) University of Texas at Austin, TX 78712 USA; e-mail: anton.menshov@utexas.edu

The Surface-Volume-Surface Electric Field Integral Equation (SVS-EFIE) [1] is a single-source integral equation which can be formulated for solution of radiation and scattering problems on homogeneous as well as piece-wise homogeneous (composite) penetrable objects. The Method of Moments (MoM) discretization of SVS-EFIE produces three dense matrices corresponding to its three integral operators. These operators map the field from the scatterer's surface to its volume, from its volume to its surface, and from its surface to back its surface. Because of the discretization of both the surface and the volume of the scatterer the resultant dense matrices take large amount of memory and require prolonged computational time, if handled directly. In this work we demonstrate a computational framework based on the theory of hierarchical matrices (H-matrices) [2], which allows to greatly alleviate the CPU time and memory complexity of the SVS-EFIE MoM solution.

The proposed fast direct solution scheme for SVS-EFIE is different from the H-matrix accelerated solutions of alternative integral equations of electromagnetics as it requires multiplication of the non-square matrices corresponding to the product of the surface-to-volume and volume-to-surface integral operators. Since all the pertinent matrices are computed and stored in H-matrix format, their multiplication must be done according to sophisticated algorithm for so-called 'formatted multiplication' of the H-matrices. The result of multiplication is subsequently added to the H-matrix corresponding to the surface-to-surface integral operator. This is performed using special 'formatted-addition' algorithm.

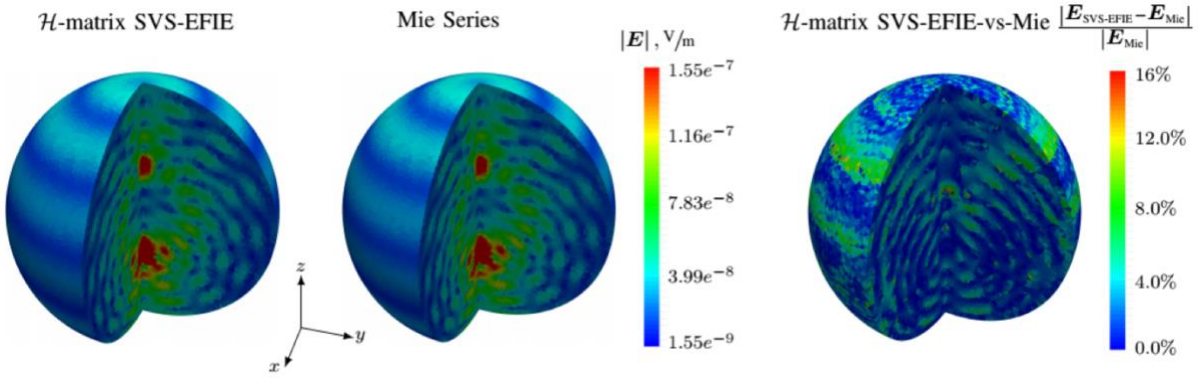

Figure 1. Solution of radiation problem for electric dipole situated near dielectric sphere.

H-matrix accelerated MoM solution of SVS-EFIE for the problem of radial electric dipole radiation at *3GHz* near homogeneous dielectric sphere is depicted in Fig. 1. Sphere has *20cm* diameter and relative permittivity of *12*. The radial dipole of moment $I \cdot l = 1A \cdot m$ is situated *40cm* away from the sphere center. The volume of the sphere is discretized with over *320* thousand tetrahedrons while it's surface is discretized with over *20* thousand triangles.

1. F. L. S. Hosseini, A. Menshov, R. Gholami, J. Mojolagbe, and V. Okhmatovski, "Novel single source integral equation for 3D scattering problems by 3D dielectric objects," *IEEE Trans. Antennas Propag.*, (early access)
2. L. Grasedyck and W. Hackbusch, "Construction and arithmetics of H-matrices," *Computing*, **70**, 2, Aug. 2003, pp. 295–334.