A Novel Hybrid SIM-SEM Method for 3D Electromagnetic Scattering Problems

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The Finite Element Method (FEM) has been studied for decades and is a very robust method for solving electromagnetic scattering problems. Yet for the open boundary problem an additional boundary condition is needed to truncate the field properly. The most popular method to truncate is Perfect Match Layer (PML); however, using PML will increase the number of unknowns. Then the hybrid FEM-Boundary Integral (FEM-BI) method uses the integral equation as the boundary condition of the FEM. Generally the problem of FEM-BI is that the integral equation part will result in a full matrix that greatly increase the memory and computation time. To improve the FEM-BI method, the surface of the integral method can be chosen carefully to make the integral equation matrix Toeplitz. This method has been applied to open boundary problem such as cavity-back aperture mounted on a PEC plate, but not for real a 3D problem with closed outer boundary.

In this paper a new method that hybridize the Spectral Integral Method (SIM) and Spectral Element Method (SEM) is proposed. This method can be thought as a high order version of FEM-BI method but with a fast algorithm. This method utilizes the spectral convergency property in both SEM part and SIM part. The difference of this method and conventional FEM-BI in terms of FEM part is that high order basis functions are used in SEM part. Gauss-Lobatto-Legendre (GLL) points and polynomials are used to construct the vector basis functions for an arbitrary order. Due to the property of the GLL points this method is exponentially convergent. The difference in BI part is that the block Toeplitz property of the SIM matrix is utilized to reduce the storage and computation time. Between SIM and SEM the interpolation of two sets of basis functions are used. This method has been successfully applied to 3D scattering problems with closed outer boundary. The computational complexity in terms of memory and CPU time is analyzed. Several numerical results will be presented to show the capability of this method.