A Three-Dimensional BCGS-FFT Method for Inhomogeneous Anisotropic Scatterers with High Dielectric and Magnetic Contrasts

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Although computational capabilities have been substantially enhanced over the last few decades, fast and accurate forward solvers for scattering and imaging applications are still attracting much attentions with new advances. To deal with the scattering of dielectric objects, methods involving integral equations are attractive because of reduced number of unknowns. As a conventional way to solve integral equations, the method of moments (MOM) with N unknowns takes about O(N^3) CPU time and O(N^2) computer memory. This requirement is prohibitively expensive for large problems, especially for volume integral equations where N is proportional to the volume of the 3D inhomogeneous scatterer. CG-FFT method was proposed to reduce the computational complexity by employing the fast Fourier transform to calculate convolution operators in the integral equations. The resulting linear system is then solved by an iterative method, namely conjugate gradient (CG) method. Therefore, the requirements for CPU time and computer memory can be greatly reduced. Furthermore, CG-FFT method is accelerated by the stabilized biconjugate-gradient FFT (BCGS-FFT) method (X. Xu, Q.H. Liu, Z.Q. Zhang, J. Appl. Comput. Electromag. Soc. 17, 1, 97-103, 2002). However, most of the work mentioned above considers only homogeneous anisotropic scatterers and/or scatterers with non-magnetic materials with a low contrast.

This work proposes a BCGS-FFT method for inhomogeneous anisotropic s-catterers with high dielectric, magnetic and conductivity contrasts. The inhomogeneous anisotropic properties of the scatterers are handled by keeping the location dependent complex permittivity and permeability in the coupled electric and magnetic field integral equations. To deal with the magnetic contrast, an extra term representing the equivalent magnetic current, caused by magnetic contrast, is added to the integral equations. Then, a discretization with face-centered node points is employed to ensure the accuracy for high contrast scatterers (C.C. Su, IEEE, Trans. Microwave Theory Tech., 41, 510-515, 1993). Examples will be presented to show the effectiveness of this method.