A 3-D Spectral Integral Method for Acoustic and Electromagnetic Wave Scattering

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Due to the increasing requirements of simulating electromagnetic wave scattering from large-scale and complex structures, high-order and spectral methods have become very attractive because of their accuracy and efficiency. In this work, we propose to develop a spectral integral method, which is based on the surface integral equation, to solve Helmholtz and Maxwell's equations.

For 2-D problems, Liu et. al. have developed a fast Fourier transform (FFT) based spectral integral method (SIM) as an alternative way of solving surface integral equations (J. Liu and Q. H. Liu, IEEE Microwave Wireless Compon. Lett., 14, 3, 97-99, 2004) for arbitrarily-shaped smooth dielectric and metallic cylinders in free space. They also showed the spectral accuracy and the computational efficiency of SIM.

For realistic applications, 3-D integral equation methods are more useful and challenging. The 3-D spectral integral methods have been investigated for Poisson and Helmholtz equations, and spectral accuracy has been obtained by several researchers, such as K. E. Atkinson (K. E. Atkinson. SIAM J. Numer. Anal., 19:263–274, 1982). Recently, Ganesh et. al. further extended the 3-D spectral integral method by using spherical harmonics (M. Ganesh and I. G. Graham. J. Comp. Phys., 198:211–242, 2004). However, these methods still showed very expensive computational complexity. Moreover, spectral integral methods have not been developed for solving Maxwell's equations. Here, we propose to develop a spectral integral method using Fourier series as basis functions. It provides spectral accuracy with efficient computation, for solving 3-D acoustic and electromagnetic wave scattering problems. Since we introduce Fourier series rather than conventional spherical harmonics into the integral equation, this method is more efficient than other existing 3-D integral equation methods. Numerical examples will be presented to investigate the computational efficiency of the 3-D SIM.