Scattering From Electrically Large Rough-Surfaces via a Scalable Fast Multipole Analysis

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Studying the scattering features of three-dimensional randomly rough surfaces is a very important and challenging problem, of interest when sensing targets over the ocean and in the presence of rough terrain. We have implemented an efficient scalable multi-level fast multipole algorithm (MLFMA) for perfectly conducting and dielectric rough surfaces. The scalable software is implemented via the message-passing interface (MPI). We first demonstrate the efficiency and scalability of the MLFMA software, and then use it to analyze scattering from both perfectly conducting and dielectric interfaces. With regard to the perfectly conducting rough surface, we perform two distinct implementations for truncation of the surface. In one we truncate the surface and employ beam excitation. In the second we taper the finite rough surface into a flat interface, with this coupled to the perfectly conducting half-space Green's function. In this latter approach the rough surface is finite, but the surface is embedded within an infinite perfectly conducting half plane. We therefore employ plane-wave excitation in this latter case. In this talk we perform a detailed analysis of the distinctions between the results computed via these two approaches.

For the sea-surface problem we often employ a perfectly conducting surface, thereby necessitating an electric-field integral equation (EFIE). Finely detailed structure on the rough surface implies that we often require basis functions that are very small relative to wavelength. Under this circumstance the EFIE is typically poorly conditioned, thereby significantly slowing algorithm convergence via iterative solvers, such as the conjugate-gradient method. In this talk we also investigate a new formulation of the EFIE integral equation, which is better conditioned, thereby yielding significantly improved convergence of the numerical solution.