ABSTRACT

Rough surface scattering plays an important role in many electromagnetic (EM) applications. Analytical theories exist and are limited in their regimes of validity. At present, scattering from surfaces whose properties render the analytical theories invalid can be accurately calculated only through the use of numerical methods. However, numerical scattering models for rough surfaces are usually computationally expensive for general use in most practical applications. In this dissertation, an extremely efficient and accurate iterative method of moments based on a novel spectral acceleration (NSA) algorithm is developed for the computation of scattering from both one-dimensional (1-D) and two-dimensional (2-D) large-scale rough surfaces corresponding to 2-D and 3-D vector wave problems, respectively. For fixed frequency and surface roughness statistics, it is shown that the computational cost and memory storage requirement of the NSA algorithm is $\mathcal{O}(N_{tot})$ as the surface size increases, where N_{tot} is the total number of unknowns to be solved. The contribution of this dissertation can be summarized as follows:

- The original 1-D NSA algorithm has been generalized for the fast computation of radiation/scattering from 1-D *extremely* large-scale quasi-planar structures (QPS). New analytical formulas associated with the 1-D NSA parameters are also derived, resulting in *more flexibility* in optimizing the 1-D NSA algorithm. In addition, the “multilevel” concept is introduced to improve the accuracy of the original NSA algorithm in the case of 1-D *extremely* large-scale QPS.
- The 1-D NSA algorithm is extended to treat 2-D random rough surfaces, and the new 2-D NSA algorithm for these surfaces is derived. Appropriate spectral integral representations of the 3-D free space scalar Green’s function and the “multilevel” algorithm are developed to *efficiently* compute scattered fields from *extremely* large-scale surfaces with *relatively large* surface cross-range size.
- Numerical studies of the backscattering enhancement phenomenon for both 1-D and 2-D random rough surfaces are performed by varying the following parameters: surface statistics, surface material, polarization, and incident angle. It is found that the backscattering enhancement *strongly* depends on the above parameters.

Physical insight gained from numerical results can potentially aid in the development and assessment of future extended analytical theories.