An Operational Technique to Scattering of Objects in Complex Environment

Saba Mudaliar
Sensors Directorate, Air Force Research Laboratory, WPAFB Ohio, USA

Scattering of objects in a complex environment is an important but difficult problem. One major difficulty of the problem lies in modelling multiple scattering interactions between objects and the environment. The traditional approach is to formulate the problem as a system of coupled boundary integral equations, and seek a numerical solution. Although this approach is very accurate in quantifying the scattering cross sections of the objects, one does not get a physical picture of the underlying scattering processes and interactions. Moreover, when several different objects are present the problem becomes very complicated.

With these issues and applications in mind, we explore an operator approach to this problem where the objects are represented as operators. To illustrate the idea, we consider a single isolated arbitrarily shaped Dirichlet object in free space. Scattering of a time-harmonic wave from this object is first expressed in terms of spherical harmonic functions. On observing the behaviour of these eigenfunctions when operated by the Helmholtz operator we hence derive an operator representation for the object. This representation is valid for a class of objects that can be characterized by one singularity. Indeed, it can be generalized to more general objects. We will present details of that study in a future publication. Our focus here is to quantify the interactions of the object with the environment with relative ease and accuracy.

Using the operator representation we considered the problem of scattering of the Dirichlet object in a complex environment. Our operational approach is very convenient for quantifying the interactions of this object with the complex environment. The transparency that our approach facilitates is attractive. Moreover, we found that with this approach one can calculate the spectra of multiple objects distributed in a confined domain with relative ease, compared to traditional methods. We have considered the problem of computing the spectrum of objects in an arbitrary confined domain. The modal form of the results thus obtained is of value for understanding the physics of the problem. We have hence identified the relationship between spectra and the object size, its location, and type. Initial study based on two examples shows promise.