"Splitting Rule:" Separation of Surface and Volume Effects in Scattering

Saba Mudaliar
Air Force Research Laboratory, Hanscom AFB, MA 01731

Models used in many remote sensing applications often involve scattering from random media with rough boundaries. Approximate methods such as perturbation techniques and radiative transfer approaches have been used for such problems. Rigorous numerical solutions have been obtained for these problems but only for special cases with 2D characteristics. Numerical approaches for the general 3D problems appear too cumbersome. In the course of numerical study Giovannini et al. [*J. Opt. Soc. Am. A* **15**, 1182] found that scattering from a rough inhomogeneous medium can be decomposed into surface scattering part and volume scattering part according to the following "splitting rule":

The incoherent intensity of a composite medium with a rough interface is the sum of the incoherent intensity of a rough homogeneous surface with an effective permittivity and the incoherent intensity of the same composite medium below a flat interface. The coherent intensity is merely that of the rough effective homogeneous surface.

This kind of splitting behaviour is indeed true when the fluctuations are weak and can be readily obtained using a small perturbation analysis. However, Sentenac et al [*J. Opt. Soc. Am. A* **19**, 727] have found the splitting rule to be valid for a large range of parameters well beyond any perturbative treatment. Guerin and Sentenac [*J. Opt. Soc. Am. A* **24**, 385] have proceeded further to give theoretical support to this splitting rule.

We carried out a statistical wave theoretical analysis of this problem and found that the splitting rule holds when the surface fluctuations are weak. However, in general we did not find adequate justification for the "splitting rule". We also studied this problem using the radiative transfer approach and found that the incoherent intensity of the scattered waves consists of two parts. The first part is due to surface scattering from a homogeneous medium with background medium parameters. The second part consists of volumetric scattering from a half space whose transmission coefficient is that of a rough interface. However, the expression for intensity is an integral equation and hence the interpretation of the second term as due to volumetric scattering is not quite correct. The main point is that the radiative transfer approach also does not fully support the "splitting rule." Further conditions need to be imposed to arrive at the "splitting rule." We hence conclude that in general it is not possible to separate volume and surface effects in scattering.