Electromagnetic Scattering by Rough Surfaces with Spatially Varying Impedance

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A method is given for evaluating electromagnetic scattering by an irregular surace with spatially varying impedance. This allows examination of the effects of impedance variation and the resulting modification of rough surface scattering. Expressions are derived for the coherent field for both flat and rough surfaces, taking the form of effective impedance conditions.

Many applications of wave scattering from rough surfaces are complicated by the involvement of further scattering mechanisms. Radar propagating over a sea surface, for example, may encounter refractive index variations in the evaporation duct or spatially varying impedance due to surface inhomogeneities. This is an even greater problem in remote sensing over forest or urban terrain. The great majority of theoretical and numerical studies, most focusing on surface roughness, nevertheless treat such effects in isolation. Roughness is usually the dominant feature but impedance variation may produce further multiple scattering. Experimental validation of scattering models in complex environments remains a major difficulty, exacerbated by the lack of detailed environmental information, and it is therefore crucial to distinguish and identify sources of scattering. In addition, while numerical computation in these cases may be feasible for the perfectly reflecting surface, it can become prohibitive for more complex environments, particularly in seeking statistics from multiple realisations.

This study is motived by these considerations. We have sought to provide an efficient means to evaluate the effect of impedance variation and its interaction with surface roughness, and to derive descriptions of the resulting coherent or mean field, for both flat and irregular surfaces.

Results have been derived by use of an operator expansion: Surface currents (from which scattered fields are determined) are expressed as the solution of an integral equation, in which the effect of impedance variation is separated. The solution is written in terms of the inverse of the governing integral operator, and provided the impedance variation is not too large this inversion can be expanded about the leading term.