The locally perturbated model for the scattering of electromagnetic waves from finite conductivity two-dimensional rough surfaces

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The modelization of the electromagnetic waves scattering from rough surfaces has applications in Optics and microwave remote sensing. The rigorous problem has no analytical solution except for canonical geometries such as layered media. Approximate models have been developed on some simplifying physical assumptions such as roughness with small height or large curvature radius, compared to the wavelength, and so on. However, those approximations have limited domain of validity, and the error commited is generally unknown.

Numerical solutions of the rigorous problem have thus been developed, on one-dimensional surfaces first, and then in the 90's on two-dimensional surfaces. The most common and successfull approach for randomly rough surface scattering is the method of moments, where boundary integral equations are discretized in a linear system of dense matrix. For two-dimensional surfaces, the number of unknowns is too large for direct inversion, and only taylor-made mumerical schemes allow one to reach the often-required million unknowns.

Even then, the dimensions of the surface samples is quite limited, and avoiding the diffraction by the edges of the surface is a central issue in such simulations. The classical approach, to use a tapered beam as incident wave, has two major drawbacks for two-dimensional surfaces. First, the low-grazing incidences are out of reach, the main incidence being limited by the dimensions of the surface, to 80°, say. Second, the tapered beam is not purely polarized, with the consequence that the cross-polarized components of the scattered field are largely overestimated on whole regions of the scattering diagram.

Some of the authors have recently proposed an alternative approach called the locally perturbated plane. With a plane wave as incident field, edge diffraction can be avoided if the roughness of the surface is flattened on the edges. The classical magnetic and electric field operators appear now on both the left-hand side and the right-hand side of modified integral equations. Implementation to finite-conductivity surface such as metals in Optics and sea surface at microwaves is presented. The model is compared to approximate models such as the small slope approximation.