Rough surface scattering:
comparison of approximate methods with a boundary integral method

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The boundary integral formalism, combined with fast numerical solvers, is among the most efficient ways to deal rigorously with the time-harmonic scattering from a randomly rough surface separating two semi-infinite homogeneous media. However, despite the rapid increase in computer speeds and the recent progress in numerical methods, computation times remain quite long, mainly because the method of moments requires a Monte Carlo process. As a comparison, approximate methods remain very fast, especially when a statistical formula is obtained. But no estimation of the error is provided with such formulas. For validation, approximate results can be compared to measurements, but this requires an accurate knowledge of the surface roughness. Only a few controlled laboratory experiments have been designed with this aim. These remarks have motivated this work, consisting in comparing approximate results with those obtained from the numerical solution of the rigorous integral equation.

Obviously there are too many parameters to derive general rules. Therefore, we have restricted our investigations to a few examples. First, all the random rough surfaces considered here have a Gaussian surface height distribution, since this assumption is often required to get the approximate formulas. The power spectrum $S(\mathbf{K})$ thus completes the description of the surface statistics. Two kinds of spectra have been studied: the Gaussian spectrum, typical of single scale surfaces, and a power law spectrum, because $1/f$ spectra are very popular to describe natural surfaces. A well known example is the sea surface spectrum, which can be well fitted by a f^4 law over a wide range of scales. Secondly, considering that surface scattering at grazing incidence angle cannot be accurately solved with our rigorous method, and that, away from grazing, incidence angle is not a critical parameter for approximation validity, we have used a 20° incidence angle only. Thirdly, to save computation time, we have restricted our study to metallic surfaces, or, with remote sensing applications in mind, to low penetrable surfaces like sea surface in the microwave range.

The rigorous model will be compared to approximate methods dedicated to surfaces with small slopes (the Small Slope Approximation, the Kirchhoff approximation, the Meecham-Lysanov approximation). To this end, the same incident Gaussian beam and the same surface samples have been used throughout the whole process.

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