Mean-field Theory of Light Scattering by Naturally Rough Surfaces

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Scattering from rough surfaces is a subject of interest in many diverse research areas, such as optics, spectroscopy, remote sensing, sonar detection, radar imaging. The two classical and widely used methods to study scattering from two-dimensional rough surfaces are the Rayleigh or small-perturbation method (SPM) and the Kirchhoff or physical optics approxi-mation (KA) [1, 2]. The former is valid for small heights and slopes, and the latter is valid for high frequencies and large radii of curvature. In these regions of the surface parameters the two methods give useful results, but they do not overlap except those surfaces that have small and smooth roughness [3].

Therefore, strong interest persists to develop new analytical approaches to obtain better solu-tions in a domain where the accuracy of neither the KA nor the SPM is guaranteed. This makes alternative methods such as the mean-field theory (MFT) interesting since it may bridge the gap between the SPM and the KA. The MFT has been introduced quite recently [4, 5] and has not been systematically tested in the 2D case in scattering from substantially rough surfaces having root-mean square (RMS) height comparable with wavelength of the incident radiation. In this paper the MFT is applied to calculate incoherent scattering from 2D rough natural surfaces with power-law spectra, which are typical for fractal or ocean-like surfaces. An important fact to note is that the RMS/wavelength ratio is not assumed to be a small parameter, that is why both electric field and Green's tensor involved to the integral equation for scattered intensity are calculated numerically as solutions of the reference problem characterized by averaged refractive index.

To study a validity domain of the presented approach, some computer simulations have been made for the surfaces with ocean-like spectrum. The RMS heights of the considered surfaces were well beyond the usual SPM domain. The numerical comparison between the presented modification of the MFT and other approaches [3] show surprisingly good agreement in scattering diagrams plotted in the main incidence plane for both polarization cases.

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