Diffraction corrections to the GO currents induced at the perfectly conducting smoothly corrugated surface

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To solve a wide range of diffraction problems it is desirable to express currents induced at the surface by the incident electromagnetic (EM) wave in an explicit analytical form. One of the generally used approaches to estimate currents at the smoothly-corrugated surface is the tangent plane (or Kirchhoff) approximation, when surface currents assumed to be the same as they are at the plane tangent to the surface at its every point. This approach can be seen as a local geometrical optics (GO) approximation to the surface currents.

In this paper, we present the results of solving the integral equation for surface currents at the perfectly conducting, smooth and gentle surface for steep incidence, when multiple scattering and surface shadowing can be neglected. The obtained diffraction corrections to GO values of the surface currents (up to the second order of small parameter $\sim 1/k$, where k is the wave number of the incident EM wave) depend on the local angle of incidence, surface curvatures and their space derivatives. It is shown that diffraction caused by the local surface curvature results not only in small corrections to the GO currents, but also gives rise to the surface current components orthogonal to those induced by the incident wave in the local GO limit. These current components are responsible for backscattering into the cross-polarized EM waves, which is absent in the GO limit.

The general analytical results obtained for the surface currents are applied to the specific problem of backscattering of linear and circular polarized EM wave by a statistically rough surface at normal incidence. It is shown that for linear polarization, diffraction corrections to the backscattering cross sections for the surface with anisotropic roughness, as well as the cross-polarization coefficient, depend on the azimuth angle between the surface roughness principal directions and the vector of electric field of the incident wave. For the circularly polarized incident wave, the diffraction corrections to the backscattering cross sections and the cross-polarization coefficient can be expressed through the surface-invariant parameters such as the Gaussian (total) curvature of the surface roughness spatial autocorrelation function and its derivatives.