MULTIPLE SCATTERING FROM ONE DIMENSIONAL RANDOM ROUGH SURFACES - FULL WAVE SOLUTIONS

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Using the full wave approach, integral expressions for the double scattered radar cross sections are obtained. The rough surface is assumed to be characterized by a Gaussian joint probability density function for the surface heights and slopes at two points. The surface height autocorrelation function and its Fourier transform (the rough surface spectral density function) are also assumed to be Gaussian. The expressions for the double scattered cross section are expressed as six dimensional integrals which account for the correlations between the heights and the slopes of the random rough surface.

In the high frequency limit, it is assumed that the major contributions to the double scattered cross sections come from the neighborhoods of the specular points of the surface. It is assumed that $k_0\rho \gg 1$, where ρ is the radius of curvature of the rough surface, and that $4k_0^2 \langle h^2 \rangle \gg 1$, where $\langle h^2 \rangle$ is the mean square height. The heights and the slopes of any two neighbor points on the rough surface are expanded about the mean point between them. Thus the stationary phase approximations are used to reduce the expressions for the double scatter cross sections from six to two dimensional integrals. For the stationary phase approximations to the full wave solutions it is not necessary to assume Gaussian joint probability density functions or Gaussian surface height autocorrelation functions.

The significant contributions to the double scattered intensities come from two different double scatter paths, the quasi parallel regular path and the quasi anti-parallel cross path. The shadowing effects are accounted for in the analysis of the double scatter cross sections. The total incoherent cross section is the sum of the single and the double (regular, quasi parallel and cross, quasi anti-parallel) scatter cross sections. It is found that the sharp enhanced backscatter is attributed to the anti-parallel cross term of the double scatter cross section when the rough surface mean square slopes are $\langle h_x^2 \rangle \geq 0.5$ and $4k_0^2 \langle h^2 \rangle \geq 40$. Thus the correlation length is of the order of the rms height.

The results, using the stationary phase approximations, show that there are no significant differences between the vertically and the horizontally polarized waves. Moreover, the sharp enhanced backscatter is due to the cross term of the double scatter cross section. The intensity fluctuations about the backscatter directions are due to interactions between the scattered intensities at the two points on the rough surface. These also appear in the experiments. Preliminary computations using the full wave six dimensional integrals indicate that the double scattered fields are distinctly polarization dependent. These results are also more sensitive to the fluctuations in the mean square height than the corresponding high frequency results. The high frequency full wave results are nevertheless indicative of the backscatter enhancement phenomenon that has been observed in numerous experiments.