Scattering From Large Amplitude, Short Period Surface Roughness

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There currently is a great deal of interest in altering the electromagnetic properties of a body by coating it with metamaterials; such alterations may affect scattering from the body. This paper focuses on altering the scattering properties of extended surfaces through the introduction of large amplitude, small period roughness on the surface. That is, rather than using artificial coatings, this study is concerned with modifying the scattering properties of the surface through the introduction of surface features that are constructed of large amplitude, sub-wavelength features.

More specifically, this paper will review some of the analytical/numerical methods that have been developed to analyze the effects of sub-wavelength surface structure. Because of its ability to deal with multiple scattering on the surface, we start with the Method of Ordered Multiple Interaction or MOMI to compute the current on the extended surface. We have found that for sinusoidal surface roughness, MOMI is able to very accurately solve for the current induced on the surface even into the range of large amplitude, small period (LASP) roughness. For TE polarization and a period less that one-half the electromagnetic wavelength, the current is found to be very peaked about the surface crests such as one might expect based on the edge-like behavior at the surface crests. For TM polarization and a similar restriction on the surface period, the current seems to concentrate in the troughs of the surface and ride up the sides of the trough in a standing wave pattern. Because of this behavior of the currents, the phase difference between the TE and TM scattered fields are given by the electrical path difference between the crests and the troughs for this LASP roughness. These LASP surfaces also specularly reflect the incident field.

If we perturb the surface from a sinusoidal pattern to some other form of periodic roughness, MOMI generally fails to converge. As long as the surface is periodic and the illumination is a plane wave, we have developed another method that reduces the problem to solving for the current on one period of the surface. This can be done by simple matrix inversion although the sampling must be very dense, e.g., 200 points per wavelength.

For surfaces containing spatially compact LASP features, we discuss a technique that is capable of dealing with such roughness. The approach entails segmenting the surface into three regions; one to the left and one to the right of the LASP region and the LASP region. The integral equation starts with thee three regions in isolation and then iterates to account for the interaction between the three. A discussion or the behavior of this approach will be presented.