The Single Scattering Subtraction Method For Multi-Frequency Surfaces

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The Single Scattering Subtraction (S^3) method is a technique for computing the complete singscattering current induced on a perfectly conducting rough surface by an incident field. While it is frequently assumed that the Kirchhoff current is the only single scattering part of the total current this has previously been in error. In particular, it has previously been shown that by using S^3 it is possible, for a single sinusoidal surface, to numerically obtain the $1/k_o$ correction to the Kirchhoff current, with k_o the electromagnetic wavenumber; this is the next term in the Luneberg-Kline asymptotic series for the single scattering part of the total surface current. From a more physical point of view, this new result extends the tangent plane nature of the Kirchhoff current to a "bent tangent plane" approximation because it involves the surface curvature at the point of tangency on the rough surface. Another very important aspect of this result is that it is accompanied by a very clear range of applicability for the peak amplitude and period of the surface. This result comes from the fact that S^3 contains an infinity when $k_o = k_s$ for TM or vertical polarization and $k_o = 2k_s$ for TE or horizontal polarization where k_s is the wavenumber of the sinusoidal surface. While it is not immediately obvious as to the source of these two particular values of electromagnetic wavenumber, it is suspected to be due to the possible presence of surface waves near these values and the subsequent failure of a "single scatter" and "multiple scatter" decomposition of the surface current. This is a point that is presently under study. It should be noted that these infinities can be avoided through the use of a finite surface and the effect of truncating the surface has been presented previously by means of an empirical relationship for TE polarization. Such a result has not been obtained yet for TM polarization.

All of the above results were obtained for a single sinusoidal surface. It is clearly of interest as to its applicability of the results to a multi-frequency surface. A great deal of computations has been carried out to determine the effect of multi-frequency surfaces on S^3 and these will be presented. Surprisingly, it was found that the empirical relationships for both TE and TM polarizations, i.e., the curvature results, continue to be valid provided one switches from peak surface amplitudes to the root-mean-square (rms) amplitudes. In addition, it is the rms surface slope (and sometimes the surface curvature) that seems to be the determining factor in assessing the range of validity of these results. These results suggest that the method can be applied to truly rough and possibly randomly rough surfaces.