Using the full wave approach, the quasi specular contributors to the scattered fields from the large scale surface roughness as well as the Bragg-like diffusely scattered fields from the small scale surface roughness are accounted for in a unified self-consistent manner. Thus the full wave computer codes for the scattering cross sections contain ground truth data only. It has been shown how these full wave computer codes can be used to predict the surface parameters (rms height and slope) of the lunar surface based on Apollo 14 and Apollo 16 measured data. It is also shown that the unified full wave solutions are in good agreement with the data taken during the Apollo 14 and 16 missions and questions raised by the discrepancy between the earlier reported analytical results and the Apollo data are addressed (see Fig. 1).

In these earlier results, a small slope approximation of the full wave results were used and the rms slopes considered were less than 60. The bistatic quasi specular Apollo measurements were taken from near normal to near grazing incident (and scatter) angles. It was shown that for fixed rms slope the angular location of the peak of the (specular) scatter cross section depends primarily upon the rms height (see Fig. 2) while for a fixed rms height, the relative level of the scatter cross section depends primarily upon the rms slope (see Fig. 3).

In this work the small slope approximations of the full wave solutions are not used and the results are applicable to lunar and planetary surfaces with rms slopes less than 0.5. The basis for this analysis is the original full wave solution which are obtained from an iterative (single scatter) solution of the rigorous generalized telegraphists’ equations. These original full wave solutions are restricted to surfaces with small to moderate slopes, however unlike the small perturbation solutions they are not restricted by the assumption that the surface height (in wavelengths) and slopes are of the same order of smallness. To account for larger undulations in the surface slopes, use is also made of the full wave scattering cross section modulation for arbitrarily oriented pixels or patches (that are larger than the surface height correlation length). Thus the incoherent diffuse radar cross sections, for multiple scale composite rough surfaces are obtained upon averaging the scatter cross sections of the randomly oriented patches. It is shown that the normalized incoherent diffuse scatter cross sections for the rough surfaces are stationary over a broad range of the assumed patch sizes.
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**Fig. 1.** Comparison of the unified full wave solution with other models.

![Graph showing comparison of unified full wave theory with other models](image1)

**Fig. 2.** Unified full wave scattering cross sections for a fixed mean square slope and various correlation lengths and mean square heights.

![Graph showing unified full wave scattering cross sections](image2)

**Fig. 3.** Unified full wave scattering cross sections for a constant mean square height and various correlation lengths and mean square slopes.

![Graph showing unified full wave scattering cross sections](image3)