Planetary surface characterization using dual-polarization radar observations

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The dual-polarization radar observations are a powerful, cost-effective tool to characterize both the dynamical and the physical properties of the terrestrial planets, moons, and the small bodies of the Solar System. The number of radar-observed asteroids and comets has increased rapidly during the last five years, allowing us to compare and contrast the radar scattering properties of different small-body populations and compositional types.

Our goal is to improve the methods that allow us to utilize the dual-polarization radar measurements to derive information on the targets' chemical composition, bulk density, porosity, or the structural roughness of the near-surface volume. We find that it is also possible to distinguish the echo scattered by the decimeter-scale boulders from the echo reflected by the surrounding regolith. The decimeter-scale boulders can be suggestive of the collisional history and the internal structure of the target.

METHODS

In a typical planetary radar measurement a circularly polarized signal is transmitted using either a frequency of 2380 MHz (wavelength of 12.6 cm) or 8560 MHz (3.5 cm). The echo is received simultaneously in the same circular (SC) polarization and the opposite circular (OC) polarization as compared to the transmitted signal. The delay and Doppler frequency of the signal give highly accurate astrometric information, and the received echo power and polarization are suggestive of the physical properties of the target's near-surface. The penetration depth of the signal is typically a few wavelengths depending on the absorption of the material. If the surface is smooth and the effective near-surface volume is homogeneous in the wavelength scale, the echo is received fully in the OC polarization. Wavelength-scale surface roughness or boulders within the effective near-surface volume increase the fraction of the echo power received in the SC polarization [1, 2].

The radar reflectivity of the target can be described using the radar albedo. The OC-polarized part of the echo is composed of a quasi-specular component and a diffuse component. Traditionally, the OC radar albedo has been treated as a product of the Fresnel reflection coefficient (at normal incidence), R_F, and the backscatter gain factor, g. [3]. For any smooth surface (radii of curvature larger than a wavelength), $g = 1$. The surface roughness has been described with $g > 1$, or using the circular-polarization ratio (SC/OC). However, there has been a lack of methods to determine R_F independently, or to distinguish how different scattering processes affect g or the circular-polarization ratio.

Instead of using a single parameter to describe the surface roughness, we introduce three linear regression parameters that allow for a more sophisticated approach to distinguish between the different scattering processes that may take place on planetary surfaces, and discuss the interpretations for different types of targets.

REFERENCES

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