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Computational Analysis of the Light Scattering Characteristics of Lunar Regolith Particle Shapes from the Apollo 11 Mission

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Most of the experimental and computational studies on the optical scattering characteristics of lunar regolith particles have been conducted on planetary analogs of lunar dust or virtual simulants due to the limited availability of actual regolith particles. Recently, using the advancements in X-ray Nano Computed Tomography (XCT), we imaged the exact three-dimensional (3D) morphological features of actual regolith particles from Apollo 11 and Apollo 14 missions [1]-[2]. These 3D maps allow more accurate characterization of the optical scattering characteristics of actual lunar regolith particles. We selected the 3D shapes of 25 regolith particles collected during the Apollo 11 mission and calculated their light scattering characteristics. The particles ranged in size from 400 nm to 1000 nm in effective radius, where the effective radius is defined as the radius of the sphere with the same volume as the lunar regolith particles. As the SCS of a random particle with an asymmetric shape depends on its orientation with respect to the direction of the incident wave, we have adopted a rotational average of each particle's desired characteristics under plane wave excitation. Our preliminary study focuses on the effect of 3D shape on the first resonance wavelength (RW) and the corresponding peak scattering cross-sectional (SCS) area of the lunar particles. We used the Discrete Dipole Approximation (DDA) based solver DDSCAT for our simulations due to its computational efficiency in analyzing randomly oriented particles with complex shapes. The dielectric properties of basaltic glass were assigned to the lunar regolith particles in the computational analysis. To illustrate the effect of shape on scattering characteristics, we compared the optical scattering characteristics of the considered regolith particles with spherical and ellipsoidal particles of equal effective radius. Our computational results show that actual regolith particles demonstrated a 20 % reduction in the resonance wavelength compared to spherical particles of the same effective radius. This highlights the importance of considering the effect of shape on the optical scattering characteristics of lunar regolith particles.

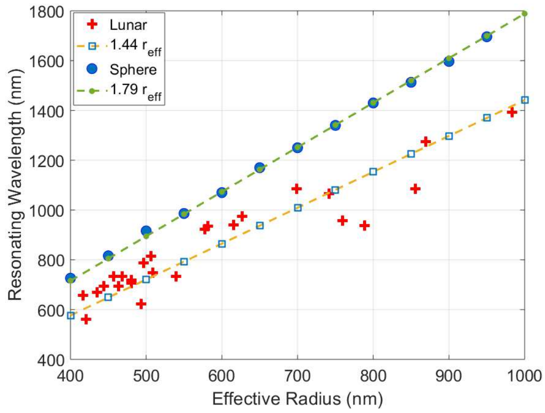

Figure 1. Comparison between the resonance wavelength of lunar regolith particles with the imaged 3D morphologies and spherical particles of the same effective radius. For each set of data, the best linear fit is also displayed.

References

[1] E. J. Garboczi, "Three dimensional shape analysis of JSC-1A simulated lunar regolith particles," *Powder Technology*, vol. 207, no. 1, pp. 96–103, Feb. 2011.

[2] S. Baidya, M. Melius, A. M. Hassan, A. Sharits, A. N. Chiaramonti, T. Lafarge, J. D. Goguen, and E. J. Garboczi, "Optical Scattering Characteristics of 3D Lunar Regolith Particles Measured using X-Ray Nano Computed Tomography," *IEEE Geoscience and Remote Sensing Letters (In Review)*, 2021.