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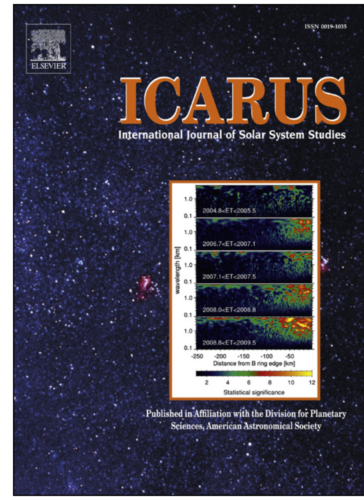

Laboratory Observations and Simulations of Phase Reddening

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Laboratory Observations and Simulations of Phase Reddening

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Abstract

The visible reflectance spectrum of many solar system bodies changes with changing viewing geometry for reasons not fully understood. It is often observed to redden (increasing spectral slope) with increasing solar phase angle, an effect known as phase reddening. Only once, in an observation of the Martian surface by the Viking 1 lander, was reddening observed up to a certain phase angle with bluing beyond, making the reflectance ratio as a function of phase angle shaped like an arch. However, in laboratory experiments this arch-shape is frequently encountered. To investigate this, we measured the bidirectional reflectance of particulate samples of several common rock types in the 400-1000 nm wavelength range and performed ray-tracing simulations. We confirm the occurrence of the arch for surfaces that are forward scattering, i.e. are composed of semi-transparent particles and are smooth on the scale of the particles, and for which the reflectance increases from the lower to the higher wavelength in the reflectance ratio. The arch shape is reproduced by the simulations, which assume a smooth surface. However, surface roughness on the scale of the particles, such as the Hapke and van Horn (1963) fairy castles that can spontaneously form when sprinkling a fine powder, leads to monotonic reddening. A further consequence of this form of microscopic roughness (being indistinct without the use of a microscope) is a flattening of the disk function at visible wavelengths, i.e. Lommel-Seeliger-type scattering. The experiments further reveal monotonic reddening for reflectance ratios at near-IR wavelengths. The simulations fail to reproduce this particular reddening, and we suspect that it results from roughness on the surface of the particles. Given that the regolith of atmosphereless solar system bodies is composed of small particles, our results indicate that the prevalence of monotonic reddening and Lommel-Seeliger-type scattering for these bodies results from microscopic roughness, both in the form of structures

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