PHYSICS-BASED RENDERING OF IRREGULAR PLANETARY BODIES. Carolina Aiazzi[1], Marco B. Quadrelli[1], Aaron Gaut[1], and Abhinandan Jain[1], [1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109, U.S.A..

Abstract: Accurate prediction or estimation of the lighting conditions on the surface of planetary and small bodies is crucial for mission planning purposes. Physically-based techniques strive to simulate reality by using principles of physics to model the interaction of light and objects. The radiative transfer is the physical phenomenon responsible for the energy transfer when the light interacts with matter. Being able to reproduce the radiative transfer model would be valuable for space simulations and computer vision. Nevertheless, modeling how light interacts with a regolith surface is quite complicated, since it means that sextillions of photons are interacting each second with trillions of particles on the surface, [5].

Bruce Hapke was able to demonstrate a theory to model these interactions, [1]. Before his theory, the lighting scattering models have been very approximated since they were based on empirical laws, with no attempt to represent the scattering behavior physically, [6].

On the other hand, the Hapke model is based on a physical description of the multiple scattering behavior of a particulate surface, and it uses a physical model instead of an empirical law to parameterize most of the effects that play a significant role in light scattering by regolith. The model includes the effects of microstructure, opposition, multiple scattering, and macroscopic roughness, described in [2] and [3]. Furthermore, wavelength-dependent effects, such as albedo and single-scattering albedo, are considered as well. The source of direct radiation is the Sun, expressed in physical units, and mutual illumination of individual bodies, as well as self-illumination, have been implemented by Hapke, Lambertian, and Oren Nayar radiation models.

This work describes the development of a tool for physically-based renderings using high fidelity models such as the Hapke model. For this purpose, Blender's Cycles ray tracing rendering engine has been used, and the custom shaders have been implemented in Open Shading Language (OSL), a shading language developed by Sony Pictures Imageworks, [7], [4].

A series of tests have been carried out to investigate the correctness of the custom shader and to better understand the contribution of each effect, as well as to compare them with real images or other software with similar purposes.

The inability to observe terrain detail, in regolith bodies, at low phase angles (opposition) is due to two mechanisms: the shadow-hiding and the coherent backscatter opposition effect. As shown in Figure 1, the Hapke BRDF (Bidirectional Reflectance Distribution Function) is the only one that takes into account those opposition effects. Figure 1 illustrates simulated images using different lighting models, with the opposition effect clearly apparent in the Hapke model image.

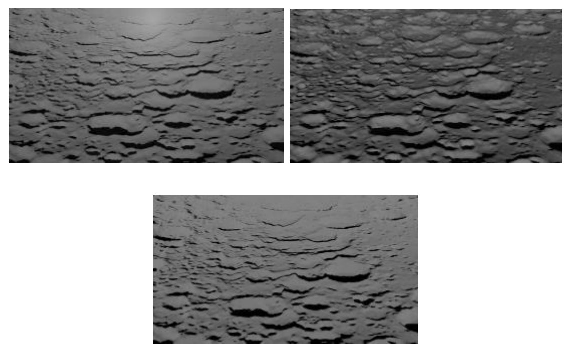

Figure 1. Comparison between the Hapke (top left), the Lambertian (top right), and the Oren Nayar model (bottom), applied to the far side of the Moon.

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References:

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