Photometric modeling of a cometary nucleus: taking Hapke modeling to the limit

Conference or Workshop Item

PHOTOMETRIC MODELING OF A COMETARY NUCLEUS: TAKING HAPKE MODELING TO THE LIMIT. B. J. Buratti (JPL), M. D. Hicks (JPL), L. Soderblom (USGS), J. Hillier (Grays Harbor College), D. Britt (U. Tenn.)

In the past two decades, photometric models developed by Bruce Hapke have been fit to a wide range of bodies in the Solar System: The Moon, Mercury, several asteroids, and many icy and rocky satellites. These models have enabled comparative descriptions of the physical attributes of planetary surfaces, including macroscopic roughness, particle size and size-distribution, the single scattering albedo, and the compaction state of the optically active portion of the regolith. One challenging type of body to observe and model, a cometary nucleus, awaited the first space based mission to obtain images unobscured by coma.

The NASA-JPL Deep Space 1 Mission (DS1) encountered the short-period Jupiter-family comet 19/P Borrelly on September 22, 2001, about 8 days after perihelion. Prior to its closest approach of 2171 km, the remote-sensing package on the spacecraft obtained 25 CCD images of the comet, representing the first close-up, unobscured view of a comet's nucleus (1). At closest approach, corresponding to a resolution of 47 meters per pixel, the intensity of the coma was less than 1% of that of the nucleus. An unprecented range of high solar phase angles (52-89 degrees), viewing geometries that are in general attainable only when a comet is active, enabled the first quantitative and disk-resolved modeling of surface photometric physical parameters.

The geometric albedo of Borrelly is 0.029 ± 0.006, comparable to the dark hemisphere of Iapetus, the lowest albedo C-type asteroids, and the Uranian rings. The Bond albedo, 0.009 ± 0.002, is lower than that of any Solar System object measured. Such a low value may enhance the heating of the nucleus and sublimation of volatiles, which in turn causes the albedo to decrease even further. A map of normal reflectance of Borrelly shows variations far greater than those seen on asteroids. The two main terrain types, smooth and mottled (2), exhibit mean normal reflectances of 0.03 and 0.022.

Borrelly's physical photometric parameters are typical of other small dark bodies. The nucleus exhibits significant variations in macroscopic roughness, with the oldest, darkest terrain being slightly smoother. This result suggests the infilling of low-lying areas with dust and particles that have not been able to leave the comet. The surface of the comet is backscattering, but there are substantial variations in the single particle phase function. One region scatters isotropically (like cometary dust), suggesting that its regolith is controlled by native dust rather than by meteoritic bombardment.

Work performed at NASA's Jet Propulsion Laboratory, California Institute of Technology.

(1) Soderblom, L. et al. (2002). *Science* **296**, 1087.
(2) Britt, D. et al. (2002). LPSC Abstract 1686.