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THE NEAR-INFRARED POLARIZATION AND COLOR OF COMET HALLEY: WHAT CAN WE LEARN ABOUT THE GRAINS?

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The near-infrared polarization and JHK colors of light scattered by dust grains in comet Halley were measured over a wide range in phase angle and heliocentric distance (Ref. 1). Colors were *redder* than solar with no statistically significant variation with phase angle, heliocentric distance, or pre- and post-perihelion. This suggests, but does not guarantee, that the grain population did not change drastically over time and that the data may be combined and modeled. However, short-term variations in visible polarization (Ref. 2) and dust albedo (Ref. 3) were seen in Halley. Also, near-infrared colors became systematically bluer after our observations were completed (Ref. 4).

The near-infrared colors of Halley fall in the range of those of other comets. Red JHK colors are typical of the scattering by size distributions of particles with effective size larger than a few microns for a wide range of materials, even for constant refractive index (Ref. 5). On the other hand comet nuclei may have similar near-infrared colors (Refs. 6, 7). So except for ruling out a significant cross section of small (Rayleigh) grains, JHK colors alone may not be particularly diagnostic of grain properties. Modeling of both polarization and color is *potentially* more powerful.

The near-infrared polarization is similar to the visible polarization of Halley and other comets in showing a negative branch at small phase angles and an approximately linear rise toward positive values at larger phase angles. This is qualitatively similar to low-albedo asteroid surfaces for which the negative branch is usually ascribed to double reflections with shadowing by rough surfaces (Ref. 8). However, the polarization of Halley *increases* with wavelength at large phase angles (Fig. 1), contrary to the available polarimetry of most asteroids (e.g., Ref. 9) and the interplanetary dust (Ref. 10). Future work should address this fact.

Mie theory calculations and a size distribution based on spacecraft data were used to model the near-infrared polarization and color of comet Halley (Ref. 11). Two components were needed: a "dirty" silicate and a more absorbing material similar to the composite material proposed to explain the thermal emission of several comets (Ref. 12). The silicate spheres, rather than rough surfaces, provided the negative branch. The model successfully reproduced the wavelength dependence of the polarization. This required wavelength- dependent refractive indices; in particular, the imaginary part of the index of refraction had to increase with wavelength, which is typical in absorbing materials at these wavelengths.

Numerous lines of evidence point to the presence of dark, absorbing, probably carbonaceous material in comets. Mie theory models of the near-infrared polarization and color tend to corroborate these results.

Models incorporating rough surfaces on the grains appear to be capable of matching both the negative branch of the visible polarization and the enhanced backscattering of cometary grains (Ref. 13).

One question is whether comet grains could be expected to scatter like spheres. The answer is probably not. Interplanetary dust particles are irregularly shaped aggregates with rough surfaces. Laboratory measurements and theoretical studies of rough particles show significant deviations from spheres both in phase function and the polarization. The broader question is whether compositional implications derived from rough particle models will contradict those drawn from Mie theory calculations; i.e., how model-dependent are the results? An answer to this question will help determine what we can learn about cometary dust from remote measurements of polarization and color.

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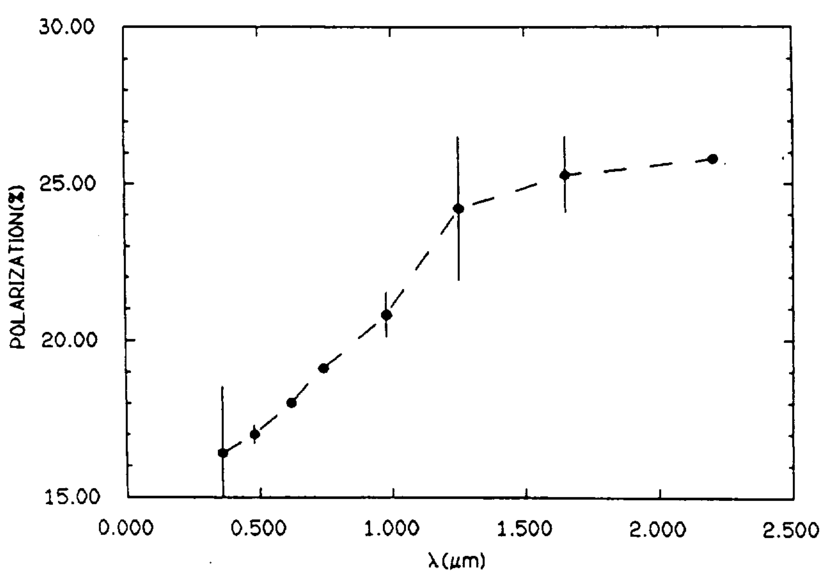

Fig. 1. Wavelength dependence of the polarization of the dust continuum of comet Halley at phase angle $\beta = 65°$. Points below 1 μm are from Ref. 14, near-infrared points from Ref. 1.