Bidirectional Reflectance Spectroscopy
4. The Extinction Coefficient and the Oppostion Effect

Bruce Hapke
Dept. of Geology & Planetary Science, Univ. of Pittsburgh

The extinction coefficient and the opposition effect in a particulate medium are discussed. Simple analytic expressions that describe these quantities are rigorously derived using a few physically realistic mathematical approximations. The particles of the medium may have a distribution of sizes and the particle density is allowed to vary with depth. The xpression for the extinction coefficient is valid for both large and small porosities and is more accurate than the one commonly used. The opposition effect arises from the hiding of extinction shadows and occurs even if the particles are transparent. The angular half-width of the opposition peak is shown to be equal to the ratio of the average particle radius to extinction length at unit slant path optical depth in the medium, and depends on both the filling factor (ratio of bulk to solid density) F and the particle size distribution.

To illustrate the theory it is fitted to observations of the moon, an asteroid and a satellite of Uranus; Europa is also discussed. For the moon a value of F=0.41 is derived, in good aggrement with data on Apollo soils. For Oberon, the width of the oppositon effect peak gives F=0.10, which is similar to values for terrestrial frosts and snow. Thus, the narrow opposition effects of the Uranian satellites do not require any unusual particles or microstructures on their surfaces. More photometric observations of Europa are needed.