On the compositional interpretation of the geometric albedo of asteroids.

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The geometric albedo is a measure of the fraction of the incoming radiation on a given bandpass (usually the visible) that is reflected by a body. Among the many different ways of defining "albedo", it is the most convenient for remote sensing purposes and hence it is widely used to characterize the intrinsic reflectivity of solar system bodies. The geometric albedo has been commonly used as an auxiliary parameter in attempts to determine the composition of those bodies. The geometric albedo has also been in some instances used to scale reflectance spectra in compositional analysis involving radiative transfer methods.

In this work I attempted to analyze the effects of surface packing on the geometric albedo of asteroids, with the intent of providing a more consistent way to link the geometric albedo of asteroids to the single scatter albedo of laboratory samples and thus facilitating the use of the geometric albedo as a mineralogical discriminant. Thus, The main goal here is to provide a meaningful answer to the question: given that an asteroid has a particular visible geometric albedo , what can we say about its composition? To this end I initially studied the relations between the slope parameter G that describes the integral phase function of asteroids in the IAU HG system to the Hapke scattering parameters. The effects of the scattering parameter on the geometric albedo are modeled by Hapke's formulation [1], which describe the scattering properties using a minimum of 5 parameters.

A genetic fitting algorithm set to perform determinist crownding [2] is used to fit Hapke integral phase functions to Lumme-Bowell integral phase functions described by values of the slope parameter G of the IAU HG system [3]. In the whole, the methodology used is similar to the one of [4], but the genetic algorith allow a more throughout investigation of the existence of multiple solutions.

As a result it was found that the weak dependence of the integral phase function on the macroscopic roughness parameter $\bar{\theta}$ prevent the existence of a unique correspondence between a given slope parameter G and the Hapke scattering parameters. Instead, a numerical method is derived that allows one to obtain the scattering parameters $(B0, h, \xi, w_v)$ as a function of p_v,G and $\bar{\theta}$ and also $(B0, h, \xi, p_v)$ as a function of w_v,G,and $\bar{\theta}$.

Next it was shown that laboratory derived scattering parameters in general produce integral phase functions that are not compatible with what is expected from asteroids. This is probably due to the fact that the packing conditions in the surface of asteroids are very different from what can be simulated in the lab, and as a consequence the lab derived $(B0, h, theta, \xi_1, ...)$ and may not be representative of asteroidal surfaces. Since w in principle is not so strongly affected by the packing of the surface, it is suggested that it is the only relevant scattering parameter to be derived in the lab. This also suggests that using lab derived Hapke parameter when trying to fit asteroid spectra with radiative transfer models might not be a good idea.

The methodology developed is used to compare the observed p_v and G of the asteroids (4) Vesta and (21) Lutetia with laboratory measurements of materials with suposedly similar compositions. As expected, it is found that the albedo and slope parameter of Vesta are compatible with measurements of unweathered terrestrial basalts with grain sizes $<= 250\mu m$. The albedo and slope parameter of Lutetia are found to be compatible with samples of the Allende CV3 meteorite for grain sizes $< 500\mu m$. The routines that allow the conversion between w and p_V (and vice-versa) are available at `http://funk.on.br/~carvano/albedo/albedo.html`

References

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