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A new polarimetric model to explain light scattering from regolith analogue

S. Deb, A. K. Sen
Dept. of Physics, Assam University, India (sanjibdeb36@yahoo.in)

Abstract

The light scattering studies of asteroid analogue are important tools to analyse the physical properties such as grain size, porosity, complex refractive index of dust grain present in regolith. The laboratory photometric and polarimetric data of scattered light from 0.3 μm Al_2O_3 as a function of phase angle have been generated with an instrument named Ellipsometer at the Dept. of Physics, Assam University, India. The bidirectional reflectance calculated from photometric data fitted well with Hapke's model for k = 0.000009. Basing on the polarimetric data of Al_2O_3, a new polarimetric model has been proposed.

1. Introduction

Remote sensing and in situ measurements on atmosphere less bodies in solar system like asteroids, satellite of planets have confirmed a thick layer of dust particle present on their surface which is known as regolith. The laboratory photometric and polarimetric study of this regolith analogue enhances the knowledge about the physical properties of dust grain present on it. The laboratory data may be analysed with the help of various theoretical models in order to understand the light scattering process more clearly.

2. L117 Ellipsometer:

The light scattering measurement instrument, L117 Ellipsometer is equipped with a red laser (λ=632.8 nm) as a source of light and a photo detector as a detector. The degree of polarisation of scattered light is measured with a polariser and an analyser drum mounted in front of the laser and the detector respectively. The different components of L117 Ellipsometer are shown in fig.1.

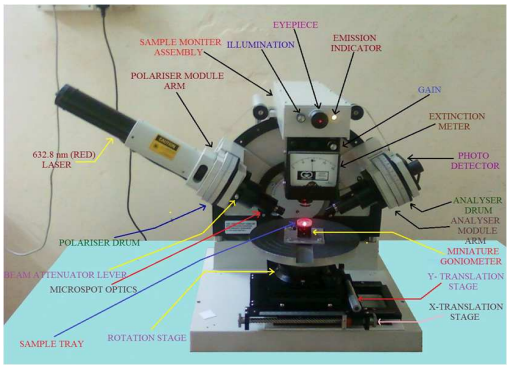

Fig. 1

3. Hapke's model:

Hapke's bidirectional reflectance model is widely used in planetary photometry to describe the light scattering from regolith. The bidirectional reflectance from photometric data can be fitted with Hapke's model [1] which requires single particle albedo ω and single particle phase function $p(g)$ for modelling. Instead of using empirical Henney-Greenstein phase function to fix the values of albedo and phase function to be used with in Hapke's formula, we have used Mie theory for the same. This method helped us to determine the single particle parameters such as diameter and refractive index (n, k) of the material. The Hapke formula [1] for bidirectional reflectance is given below,

$$r(i, e, g) = \left(\frac{\omega}{4\pi}\right)\left(\frac{\mu_o}{\mu_o + \mu}\right)\{[1 + B(g)]p(g) + H(\mu)H(\mu) - 1\}$$

where $\mu = \cos e$ and $\mu_0 = \cos e$

$$B(g) = \frac{B_0}{1 + \left(\frac{1}{h}\right)\tan\left(\frac{g}{2}\right)}$$

$$H(x)=\left[1-\left(1-\sqrt{1-\omega}\right)x\left\{r_0+\left(1-\frac{1}{2}r_0-r_0x\right)\ln\frac{1+x}{x}\right\}\right]^{-1}$$

$$r_0=\frac{2}{1+\sqrt{(1-\omega)}}-1$$

4. Analysis of experimental data:

In fig. 2 the points indicate the experimental data of bidirectional reflectance for 0.3 µm alumina sample at λ=632.8 nm. The theoretical curve is obtained by using Hapke formula with Mie theory at same wavelength. The best fit was obtained for k = 0.000009.

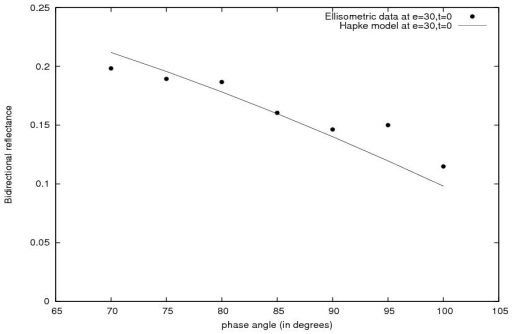

Fig. 2

In fig.3 the variation of degree of polarisation of scattered light from 0.3 µm alumina sample with phase angle at λ=632.8 nm is presented.

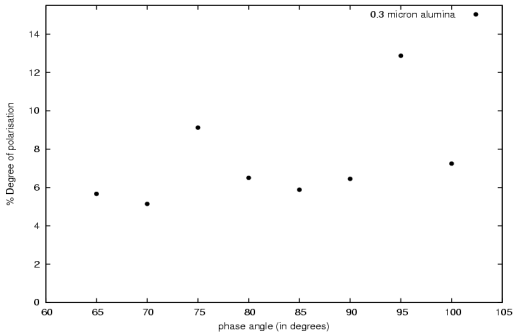

Fig. 3

5. Summary and Conclusions

In this work we have found that bidirectional reflectance derived from photometric data of 0.3 µm Al_2O_3 sample fitted well with Hapke's model curve. The best fit is obtained for absorption coefficient K=0.000009. The polarimetric data generated with ellipsometer of same Al_2O_3 sample is now being analyzed to propose a polarimetric model.

Acknowledgements

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References

[1] Hapke, B. Theory of Reflectance and Emittance Spectroscopy. Cambridge University Press, New York, NY, 1993