EPSC Abstracts
Vol. 11, EPSC2017-238, 2017
European Planetary Science Congress 2017

Behaviour of phase functions of Olivine and Augite assemblages in the wavelength range 0.3-18 μm

M. A. Salgueiro da Silva (1,2), T. M. Seixas (1,2), A. Maturilli (3), and J. Helbert (3)

(1) Department of Physics and Astronomy, Faculty of Science, University of Porto, Portugal, (2) Center for Earth and Space Research of University of Coimbra (CITEUC), Portugal, (3) Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany (massilva@fc.up.pt)

Abstract

In this work, we performed bi-directional reflectance spectroscopy measurements on single mineral assemblages of olivine and augite minerals in the wavelength range 0.3-18 μm and for several phase angles. The measured spectra show evidence for a so far unreported wavelength- and, possibly, grain size-dependent phase function for both olivine and augite samples. Two interesting spectral features were identified: change in monotonicity of the radiance versus phase angle dependence at several wavelengths; quasi-isotropic scattering in spectral regions of high absorption.

1. Introduction

Deconvolving bi-directional reflectance (BDR) spectra of intimate mineral mixtures to determine grain size and abundance of each component mineral is crucial to study the mineralogy of asteroids. Hapke's radiative transfer theory [1] provides a complete framework for modelling BDR spectra of minerals and intimate mixtures of minerals, as those forming asteroidal regoliths. According to Hapke model [1], neglecting the opposition effect for phase angles g > 15°, BDR spectra can be described by the equation

$$r = \frac{K\mu_i}{4(\mu_i+\mu_e)}\omega[p(g) + H(\mu_i/K)H(\mu_e/K) - 1] \quad (1)$$

where r is the radiance coefficient and ω is the single-scattering albedo; μ_i, μ_e are, respectively, the cosines of the incidence and emission angles; $H(x)$ is the Chandrasekhar function; K is a porosity factor; $p(g)$ is the single particle phase function. Using a wavelength-independent phase function of Henyey-Greenstein or Legendre polynomial type has become a common procedure in modelling BDR spectra in the typical UV-VIS-NIR range of 0.3-2.6 μm. This, however, may be inadequate in the mid-infrared (MIR) range, where dramatic changes in light absorption and scattering are likely to occur near anomalies in the refraction index. This work aims at testing the validity of such assumption by measuring BDR of olivine and augite mineral assemblages in the extended spectral range 0.3-18 μm.

2. Experimental details

The olivine (OL, Fo89) and augite (AUG) mineral samples used in this study were supplied from the minerals collection of the Planetary Spectroscopy Laboratory (PSL, Berlin). Four samples of each mineral were prepared in size fractions of 0-25, 25-63, 63-125 and 125-250 μm. BDR spectroscopy measurements were performed in the wavelength range 0.3-18 μm at phase angles of 30°, 45°, 60° and 75°, using a Bruker Vertex 80V FTIR spectrometer [2].

3. Results and discussion

In Fig. 1, we show the spectra measured for the olivine sample with size fraction 0-25 μm. For this sample, the variation of radiance with phase angle ($r(g)$) is strongly dependent on the wavelength. At a wavelength of about 5 μm, a monotonicity inversion takes place as radiance changes from a decreasing to an increasing function of phase angle. Moreover, the phase span of radiance spectra is larger in the region where radiance and, presumably, albedo are lower. Since $H(x)$ is an increasing function of albedo, these effects point to a complex wavelength dependence of phase function. For larger size fractions (see Fig. 2 for OL 63-125 μm), the change in $r(g)$ monotonicity is less evident but occurs at several wavelengths (8.2, 9.2,

14.5 and 15.5 μm). Actually, in the spectral regions around these wavelengths radiance phase span is negligible, indicating quasi-isotropic scattering. These are, at the same time, regions of high absorption.

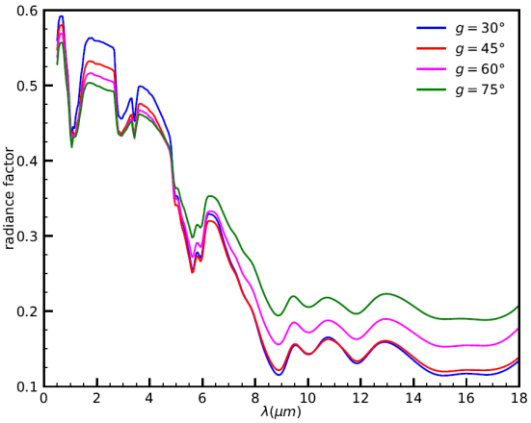

Figure 1: BDR spectra of olivine sample with size fraction 0-25 μm.

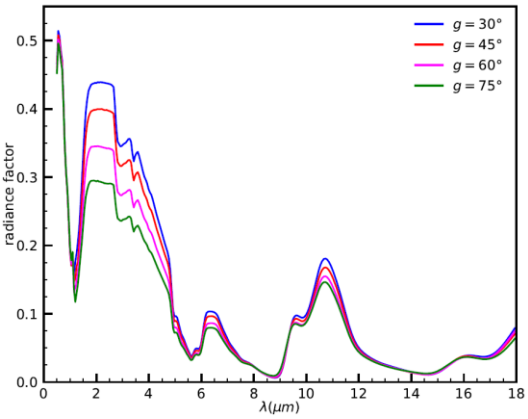

Figure 2: BDR spectra of olivine sample with size fraction 63-125 μm.

Radiance of augite samples also show evidence for a complex wavelength dependence of phase function, although no noticeable monotonicity changes in $r(g)$ are observed. As seen in Fig. 3 for the AUG 63-125 μm sample, quasi-isotropic scattering is apparent within essentially the same spectral regions as for the OL 63-125 μm sample.

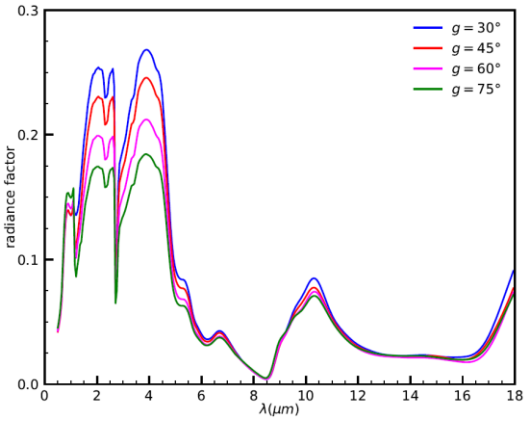

Figure 3: BDR spectra of augite sample with size fraction 63-125 μm.

4. Summary and Conclusions

We tested the validity of the wavelength-independent phase function assumption by measuring BDR of olivine and augite mineral assemblages in the extended spectral range 0.3-18 μm. Because quasi-isotropic scattering is present in both OL and AUG assemblages with grain-size dependent features, it is not clear that this is an intrinsic effect attributed to the wavelength dependence of the optical constants of olivine and augite minerals. Our results show that the application of Hapke model to olivine and augite BDR spectra in the MIR range requires a wavelength- and, possibly, grain size-dependent phase function.

Acknowledgements

This work was done under projects: UID/Multi/00611/2013, funded by FCT/MEC (PIDDAC) and FEDER through COMPETE-2020, with reference POCI-01-0145-FEDER-006922; EuroPlanet 2020 RI TA (ref. 16-EPN2-044), funded by the EU's Horizon 2020 research and innovation programme under grant agreement N° 654208.

References

[1] Hapke, B.: Theory of reflectance and emittance spectroscopy, 2nd ed. Cambridge University Press, Cambridge, UK, 2012.

[2] Maturilli, A. and Helbert, J.: The Planetary Spectroscopy Laboratory (PSL): Spectral measurements of planetary analogues from UV to FIR. 47th LPSC (2016).