EPSC Abstracts
Vol. 11, EPSC2017-887-1, 2017
European Planetary Science Congress 2017

UV-Vis-NIR spectral modeling of meteorites using novel multiple-scattering methods

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Abstract

We have measured the reflectance spectra of the Osceola meteorite, three lithologies of the Chelyabinsk meteorite (light-colored, dark-colored, and impact melt), and 30 different centimeter-sized meteorite pieces with the University of Helsinki UV-Vis-NIR integrating-sphere spectrometer. Spectral modeling for the meteorite pieces has been carried out by utilizing the SIRIS light-scattering code.

1. Introduction

Asteroids provide us information on the evolution of the Solar System. Meteorites and asteroids can be linked by matching their respective reflectance spectra. However, this is difficult because the spectral features depend strongly on the surface properties, and the surfaces of the meteorites are free of regolith dust present in the asteroids. To better interpret the spectra, we need to understand the surface differences better, for example whether the material is fresh or weathered, and gain more knowledge of the light-scattering physics involved.

2. Samples and Measurements

We have utilized the University of Helsinki UV-Vis-NIR (0.25-3.2 microns) integrating-sphere spectrometer to measure the reflectance spectra of the Osceola meteorite, three lithologies of the Chelyabinsk meteorite (light-colored, dark-colored, and impact melt)[1], and 30 centimeter-sized meteorite pieces borrowed from the mineral cabinet of the Finnish Museum of Natural History. 23 of these samples are ordinary chondrites, four are HED meteorites, one is an aubrite and one is an enstatite. The spectral measurements were carried out using a wavelength range of 250 to 2500 nm with 5-nm sampling steps.

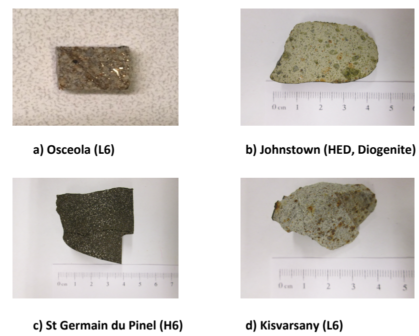

Figure 1: Four measured meteorite samples.

3. Spectral modeling

The reflectance spectra of meteorites can be modeled by combining the most common materials that dominate their spectral features, such as olivine, pyroxene, and iron. We utilize a new code that is based on SIRIS light-scattering code, which simulates light by Gaussian-random-sphere particles large compared to the wavelength of the incident light[2]. The new version models correctly the inhomogeneous nature of the wave due to the absorption in the media. For the computations, we need the complex refractive indices of the materials as input parameters. The refractive indices for olivine and iron are derived from [3], [4], and [5] (data retrieved from Jena Database for Optical Constants for Cosmic Dust and Refractiveindex.info, and further processed by A. Penttilä). The refractive indices for pyroxene were obtained by utilizing an optimization code that utilizes SIRIS-code and the measured reflectance spectrum of the material.

4. Summary and Conclusions

The modeled reflectance spectra for four meteorite samples are shown in Figure 2, and the materials used in the models are shown in Table 1. The small dif-

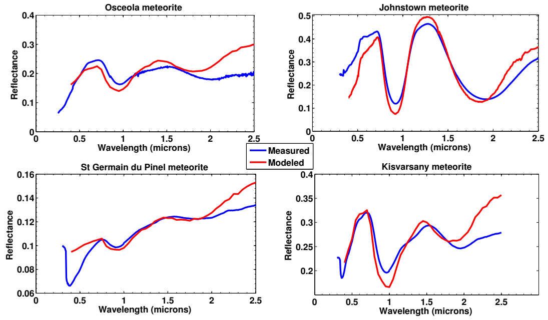

Figure 2: Measured and modeled reflectance spectra.

ferences between the measured and modeled spectra can be caused by a) small amounts of other materials than olivine, pyroxene and iron in the meteorite, b) slightly different type of olivine or pyroxene that was used in the model, and c) the presence of nanoiron in the media, which would explain the difference above 2 micrometers.

Meteorite	**Materials used in the model**
Osceola	55% olivine, 45% pyroxene, 1% microiron
Johnstown	Pure pyroxene (bronzite)
St Germain du Pinel	55% olivine, 45% pyroxene, 4% microiron
Kisvarsany	65% olivine, 35% pyroxene, 0.1% microiron

Table 1: The materials used in the models.

Acknowledgements

The research is funded by the ERC Advanced Grant No. 320773 (SAEMPL).

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