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LABORATORY SPECTROMETRY OF METEORITE SAMPLES AT VISIBLE TO NEAR-INFRARED WAVELENGTHS

Hanna Pentikäinen[1], Antti Penttilä[1], Karri Muinonen[1,2], Teemu Hakala[2], Jouni Peltoniemi[2], and Maria Gritsevich[2]
[1] *Department of Physics, P.O. Box 64, FI-00014 University of Helsinki, Finland, +358 9 1911, hanna.pentikainen@helsinki.fi, antti.i.penttila@helsinki.fi, karri.muinonen@helsinki.fi*
[2] *Finnish Geodetic Institute, Geodeetinrinne 2, P.O. Box 15, FI-02431 Masala, Finland, +358 9 295 550, teemu.hakala@fgi.fi, jouni.peltoniemi@fgi.fi, maria.gritsevich@fgi.fi*

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ABSTRACT

The composition of Near-Earth Objects (NEOs) is still largely undetermined due to scarce flyby missions and low-resolution ground-based spectroscopy at the visible and near-infrared wavelengths, which is currently the main source of information on NEO composition. The variation in NEO compositions can also be significant as the result of different dynamical pathways experienced by the NEOs. Yet, knowledge of composition is vital when planning possible mitigation techniques.

The interpretation of NEO spectra is closely tied with surface structure. NEO surfaces are usually covered with regolith, which is a mixture of mineral grains ranging from micrometers to centimeters in size. The inverse problem of deducing the characteristics of the grains from the scattering of light (e.g., using photometric and polarimetric observations) is extremely difficult. Spectrometry of meteorites can be a complementary source of information considering that unweathered meteoritic “falls” are almost pristine samples of their parent bodies. Additional radiative-transfer modelling of meteorite spectra may present a way to interconnect meteorite measurements with actual NEO spectroscopy and thus advance the determination of NEO surface structures and compositions.

We have measured reflectance spectra (350-2500 nm with a zenith angle of reflection range of ±60 degrees) of centimeter-size pieces of 18 different meteorites.

The measurements were carried out with the Finnish Geodetic Institute Field Goniospectrometer (FIGIFIGO) (Suomalainen et al., Sensors 9, 2009). Principal Component Analysis (PCA) was performed on the spectra. The analysis removes correlations between the spectra of different meteorites and finds a coordinate system, where the coordinates have the largest possible variances. These new coordinates are called principal components. Components with the smallest variances can be left out and the spectra can be represented by only a few principal components.

The analysis results in distinct groups of undifferentiated ordinary chondrites and differentiated achondrites. A plot using the first two principal components is presented in Figure 1. Our measurements expand the database of reflectance spectra of 26 meteorites obtained by Paton et al. (JQSRT 112, 2011). The spectra of meteorites found in both data sets are consistent. Furthermore, we offer a phenomenological single-scatterer (Muinonen and Videen, JQSRT 113, 2012) radiative-transfer model for the measurements. Our intention is to further expand the database of meteorite spectra and develop the joint radiative-transfer model in the future.

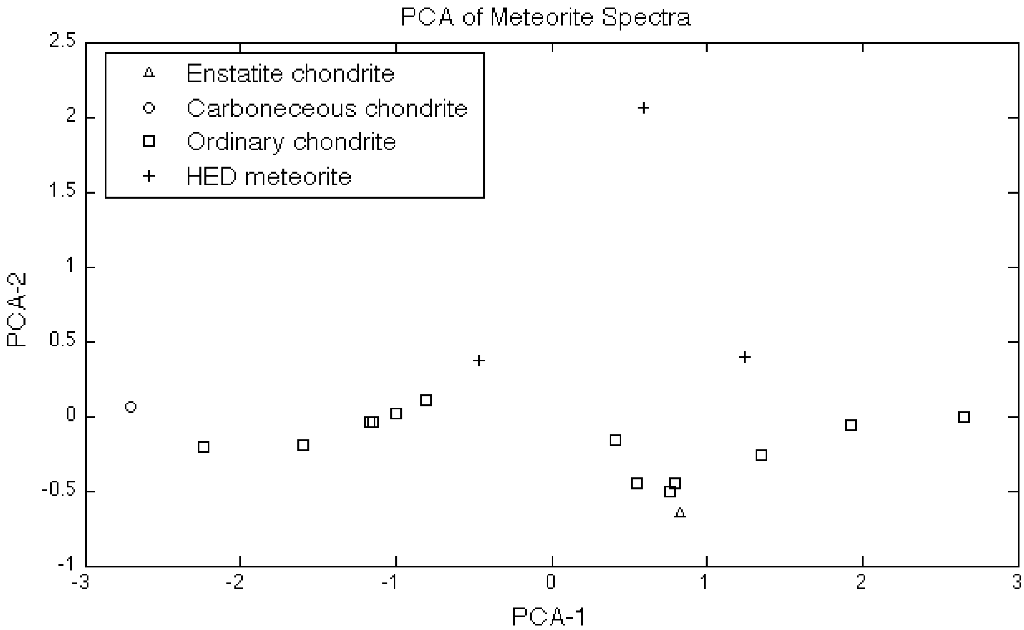

Figure 1. Measured meteorite sample spectra represented with the first two principal components.