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Ceres spectral modelling with VIR data onboard Dawn: Method and first results

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Abstract

The Dawn spacecraft [1] is at Ceres, the closest of the IAU-defined dwarf planets to the Sun and the only one found in the inner Solar System.
Despite it has been one of the most intensely observed objects in the asteroid belt, many issues about its surface and internal composition remain unanswered.
Topic of this work is the interpretation of Ceres' surface composition based on the data coming from the VIR instrument [2] onboard Dawn. We have attempted to reproduce the composition modeled by previous works, focused on Earth-based observations.

1. Introduction

The Visible InfraRed (VIR) mapping spectrometer combines high spectral and spatial resolution in the VIS (0.25-1μm) and IR (0.95-5μm) spectral ranges. VIR will provide a very good coverage of the surface during its orbital mission at Ceres. The calibration of the instrument has been improved after departure from its first target, the large asteroid Vesta. Reliable models can be performed on the basis of the measured spectra.

2. Method

In order to model the measured spectra, we have taken into account Hapke's radiative transfer model [3], which allows one the inference of the composition, the relative abundances of the spectral end-members, and the grain size. The optical constants of the spectral end-members are obtained by applying the methodology described in [4] to IR spectra reflectance obtained from the RELAB database.

The observed spectra of Ceres surface are affected by thermal emission that prevents a comparison with laboratory data. Thus to model the whole wavelength range measured by VIR, the thermal emission is modeled together with the reflectance, thanks to the link between emissivity (ε_λ) and the single scattering albedo (w): $\varepsilon_\lambda = H(\mu,w) \times \gamma(w)$, being μ the emission angle and H the Ambartsumian-Chandrasekhar function [3].
Calibrated spectra are first cleaned by removing artefacts. The best fit is obtained with a least square optimization algorithm. The S/N is calculated and is used to weight the different parts of the spectra during the fitting procedure. For further details on the method, see reference [5].

3. Results

The possible end-members responsible for the spectral features on Ceres are those suggested by [6,7,8,9,10]. Amorphous carbon [11] is used as featureless, dark component. The best fit is obtained with the following composition: 86% amorphous carbon, 8% brucite, 6% cronstedtite, all with about 50 μm grain size. A few percent of saponite, dolomite and magnesite marginally improve the fit. The model can fairly reproduce the spectra in the range 2.0 - 4.5 μm, except in the range 2.5 – 2.9 μm in which there is a strong absorption band. This latter range is not modeled in literature, being severely hindered by Earth's atmosphere.

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