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Photometric correction of VIRTIS spectra of 67P/CG: empirical approach

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Abstract

In this work, a photometric correction, based on the empirical approach already tested successfully on Vesta [1], is applied on VIRTIS data of comet 67P/Churyumov-Gerasimenko. Preliminary results are discussed.

1. Introduction

The Visible, Infrared and Thermal Imaging Spectrometer (VIRTIS) [2] onboard the ESA Rosetta spacecraft has been mapping the surface of comet 67P/Churyumov-Gerasimenko since August 2014.
VIRTIS is composed of two optical heads, i.e. VIRTIS-H, a high resolution spectrometer working in the near-infrared range (1.9-5.1 μm), and VIRTIS-M, a mapping spectrometer working in the visible 0.2-1 μm) and infrared (1-5 μm) spectral range.
The first data of VIRTIS revealed a very dark nucleus and the presence of opaque minerals associated with organic macromolecular materials [3].
Photometric correction is a fundamental process of data analysis, since it is aimed at removing the trends of reflectance with incidence, emission and phase angles, which can lead to a misinterpretation of data. Moreover, the retrieval of phase curves allows evaluating physical and optical properties of the surface, such as grain size, roughness and role of single and multiple scattering (e.g. [1], [4], [5]).
Different procedures for obtain a photometric correction of VIRTIS data are under development (e.g. [6], [7]).
Here we present the application on VIRTIS-M data of the empirical approach, developed by [1] and already applied on VIR/Dawn data of Vesta [1] and VIRTIS/Rosetta data of Lutetia [8]. The same procedure is currently being applied also on VIR/Dawn data of Ceres [9].

2. Approach

The photometric empirical model is based on a statistical analysis of the whole VIRTIS-M dataset, which in this case includes about 3 million spectra.
It has been applied on calibrated reflectance spectra and can be divided in the following steps:

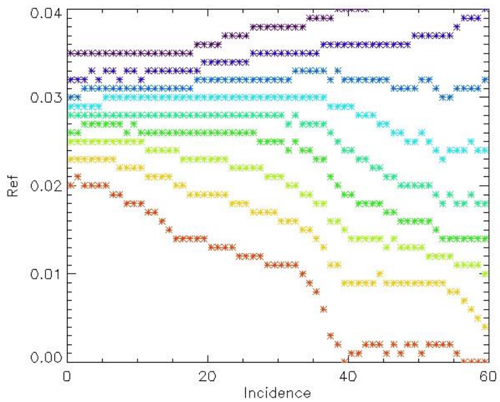
1. Identification of the most adequate disk function *D* and retrieval of equigonal albedo *(I/F)/D* in order to remove the incidence and emission effects
2. Identification of equigonal albedo families in the equigonal albedo vs phase angle scatterplot. A family is defined by equigonal albedo values of 10% (20%, 30% and so on) of brightest pixels at each phase
3. Retrieval of phase function for each equigonal albedo family
4. Correction, i.e. retrieval of the reflectance at standard illumination condition (i.e. 0° or 30° phase).

Some photometric parameters retrieved with this method, such as albedo and slope of the phase curve, can give indication about the spectral class of asteroids ([8], [9]). Therefore, in the CG case, can identify the asteroid spectral class most similar to the comet.

3. Preliminary results and discussion

The Step 1 has been applied by considered different disk functions among those present in literature, such as Lambert, Lommel-Seeliger, Akimov.
The Lambert function is not adequate for describing the photometric properties of the CG surface, since it

introduces spurious correlation of reflectance and incidence angles (Fig. 1 top). Otherwise, the other two functions well correct for the brighter regions of CG. However, even after the application of these disk functions, a residual correlation between reflectance and incidence angle is still observed for darker regions (Fig. 1 bottom) and should be understood.



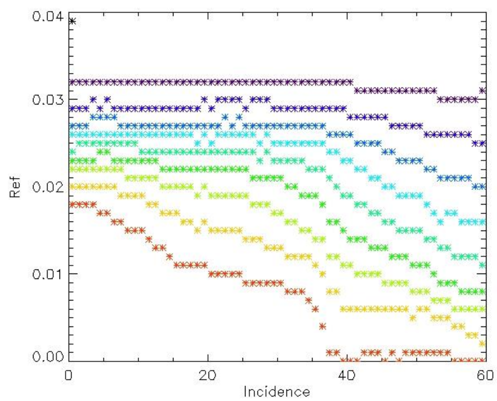


Figure 1. Equigonal albedo at 1.2 μm for different reflectance families (highlighted by different colors), obtained by applying the Lambert (top) and Akimov (bottom) disk function (results obtained for the Lommell-Seeliger disk function are similar to those obtained for Akimov). In the first case an increasing trend with incidence angle is introduced for brighter regions, whereas a residual decreasing trend is still observed for darker region whatever the disk function applied.

The application of Step 2 and Step 3 revealed that the phase functions retrieved for the different families are similar. This suggests a similar photometric behaviour across the whole 67P surface, even in active regions. However, this result should be re-discussed after the comet has passed the perihelion, when a strong increase of cometary activity is expected.

Finally, the photometric parameters describing these preliminary CG phase functions (albedo and phase slope) seem to be similar to those obtained for C-type asteroids. A detailed investigation about this comparison is in progress.

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