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Photometric study of comet 67P/Churyumov-Gerasimenko as seen by VIRTIS-H onboard Rosetta

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Abstract

In this study we present an analysis of the large dataset from H channel of VIRTIS (Visible Infrared Thermal Imaging Spectrometer) onboard ESA's Rosetta spacecraft. We focus on photometric properties of the nucleus since there are many different observation geometries and illumination conditions available. Variations of the signal with phase are reproduced with a Lommel-Seeliger model. This allows to retrieve phase function and then, by fitting the data, the single scattering albedo and asymmetry parameter for every wavelength.

1. Introduction

Since 6 August 2014, VIRTIS allows us to study comet 67P/Churyumov-Gerasimenko with two different channels ([1]): VIRTIS-M and VIRTIS-H. The first one is an imaging spectrometer working from 0.25 to 5.1µm and covering a large field of view. The second one is a point spectrometer covering the range from 1.9 to 5.0µm with a higher spectroscopic resolution. Both have already observed the comet 67P/CG under many different illumination conditions and observation geometries (e.g. between 0 and 110° phase angle). This allows us to perform a photometric study and to potentially monitor changes of the physical properties of the nucleus. In order to do that and to compare these results with [2] we work on the dataset of VIRTIS-H acquired from August 2014 to March 2015.

2. Model

Firstly, comet 67P/CG is very dark ([3]) so we assume multiple scattering can be neglected on the surface. Secondly we investigated phase angles larger than 20° which permits to neglect the opposition effect (OE) ([4]). Based on these two assumptions the signal is expected to follow the Lommel-Seeliger model:

$$I/F(i,e,g) = \frac{w}{4}\frac{\mu_0}{\mu_0+\mu}p(g)$$

$$\mu_0 = cos(i)$$

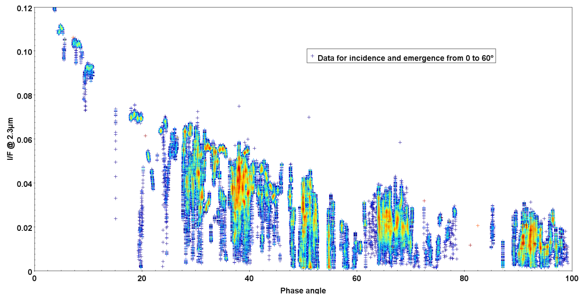
$$\mu = cos(e)$$

$$p(g) = \frac{1-b^2}{(1+2bcos(g)+b^2)^{3/2}}$$

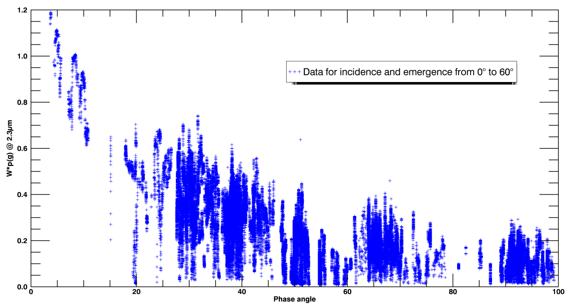
where i, e and g are respectively the incidence, emergence and phase angles for the measured reflectance I/F. w is the single scattering albedo (SSA) and b the asymmetry parameter. $p(g)$ is the phase function which is represented by a one-lobe Henyey-Greenstein function ([5]).

3. Data analysis and method

The available data are calibrated in radiance ($W/m^2/sr/\mu m$). In order to use them according to the model previously described, we convert every pixel in reflectance (I/F, represented in figure 1a) which removes any variations due to the heliocentric distance. We then use the Lommel-Seeliger model to remove angular dependencies and to obtain the product $w * p(g)$. We choose to exclude data where incidence and emergence angle are greater than 60° in order to remove illumination or viewing conditions as well as roughness effects. These angles are computed from the center of each pixels, based on the shape model 5 of Osiris. The result is displayed in figure1b where the number of pixels is larger than 90.000. We will then study the behavior of w and b along the wavelength, up to $3.0\mu m$ where thermal emission becomes noticeable. The values of w and b obtained by fitting the average I/F will be compared with values retrieved by VIRTIS-M [2] and with values measured on other comets ([6, 7, 8]).



(a)



(b)

Figure 1: (1a) Density plot of reflectance (I/F) for 10 channels aroud 2.3µm for all data from August 2014 to March 2015. (1b) Product of the Single Scattering Albedo (SSA) by phase function (p(g) where g is the phase angle). The plots are relative to observations obtained at incidence and emission angles lower than 60°.

4. Future works

Owing to the shape of the nucleus and small scale relief, roughness may deeply affect the reflectance and will be investigated further. As Rosetta continues its mission, the dataset will enlarge in the coming months. With 67P/CG passage at perihelion in August 2015, the activity in the coma will increase drastically. Surface properties may exhibit significant changes as the surface becomes warmer and more active. Possible changes in photometric parameters will be monitored and reported.

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