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Photometric properties of the surface of Lutetia as seen by OSIRIS/Rosetta

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Abstract

The asteroid (21) Lutetia has been succesfully observed on July 10, 2010, when the ESA Rosetta spacecraft flew by the small body at high relative velocity. It was the second asteroid observed in details by Rosetta, after the Steins flyby that occured 2 years before during its long interplanetary journey toward the comet 67P/Churyumov-Gerasimenko. With a diameter of $126 \times 103 \times 95\mathrm{km}^3$, Lutetia becomes the largest asteroid observed by a space probe. Because of the trajectory, the northern hemisphere could be observed while the southern remained hidden.

The images obtained in visible wavelengths with the OSIRIS cameras (both NAC and WAC) revealed a variety of craters densities and surface properties, suggesting a different geological history of the areas and different regolith properties. Here we present a spectrophotometric analysis of the surface using the OSIRIS images and we show the method we developped to generate multi-wavelengths maps from images obtained at different geometries.

1. Introduction

During the Lutetia flyby in July 2010, remote sensing instruments onboard the Rosetta spacecraft have acquired precious informations on the surface of the asteroid. The closest approach occurred at 15H45 UTC at a relative speed of 15km/s and a relative distance of 3160 km. The Narrow Angle Camera (NAC) and the Wide Angle Camera (WAC) of the OSIRIS instrument onboard Rosetta acquired images at different phase angles ranging from almost zero to more than 150 degrees. The best spatial resolution (60 m/pixel) allowed to reveal a very complex topography. Numerous sets of images have been obtained at different wavelengths from 270nm to 980nm, allowing to perform a spectrophotometric analysis of the surface. For this purpose, we used 189 images obtained with the NAC with 16 different filters conbinations, and 160 images corresponding to 10 WAC combination filters.

2. Photometric corrections

The direct comparison pixel-to-pixel between two images obtained at two different wavelengths and at different time is limited to data acquired at almost the same geometry conditions. At closest approach, a delay of few seconds between two acquisitions imply an important change of spatial resolution and phase angle. Moreover, apparent variegation of the surface depends also on shadows and incidence angles that are not representative of the real photometric properties of the regolith.

To generate multi-wavelengths maps of Lutetia, we used the 3D shape model from [1, 2] to create simulated images using the OASIS simulator (LAM). An auto-correlation algorithm was used to adjust OSIRIS data with simulated images on which the local conditions of illumination are known for each pixel (i.e., phase, incidence and emission angle).

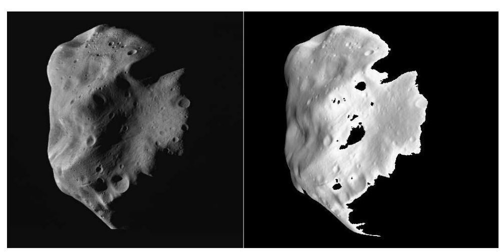

Figure 1: Left : OSIRIS NAC image obtaind around the closest approach at 630 nm. Right : Incidence angles computed using the 3D shape model.

Photometric properties were then derive using either [3] photometric law or [4] semi-empirical law. On each case, photometric parameters were first obtained for the full set of pixels on each image by looking for the minimum chi square between the measured and the modeled reflectances. Each image was then corrected assuming a specific phase angle. We will present those images and the areas corresponding to a different photometric properties.

The surface of Lutetia was then analyzed directly facet per facet on the 3d shape model. For each facet located on the northern hemispher, the phase fonction was obtained and photometric parameters were derived independently. We will show the albedo, roughness and opposition effects parameters and we will discuss the physical implications on the surfaces properties of Lutetia. The northern Beatica region that corresponds to a young surface show important variations of the albedo. We will dissuss these variations with the spectral slope.

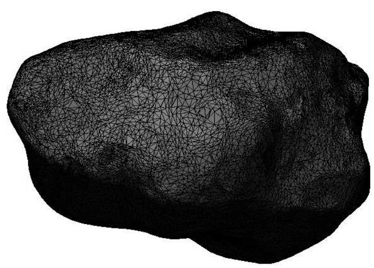

Figure 2: 3D view of the Lutetia shape model (low resolution) color-coded with the computed surface albedo.

References

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