EPSC Abstracts
Vol. 5, EPSC2010-200, 2010
European Planetary Science Congress 2010

The shape and physical properties of asteroid 21 Lutetia from OSIRIS images

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Abstract

The Rosetta spacecraft of the European Space Agency flew by the asteroid 21 Lutetia on July, 10, 2010 on its way to its final target, comet 67P/Churyumov-Gerasimenko. We report here on a preliminary interpretation of the images of the asteroid acquired by OSIRIS, the imaging system aboard Rosetta. These images are combined with pre-flyby light curves and adaptive optics measurements to retrieve the shape and the rotational parameters of the asteroid. The bulk physical properties: surface, volume, moments of inertia, gravity field, are then deduced from the shape.

1. Introduction

Ground-based pre-flyby observations yielded a preliminary picture of 21 Lutetia (hereafter "Lutetia") as an elongated body with axes of $124 \times 101 \times 93$ km (Fig. 1) with error bars between 4 and 13 km (Z-axis) [6, 5] The orientation of the spin pole is given by (RA, Dec) = $(52 \pm 5, +12 \pm 5)$ deg and the spin period is $P = 8.1682$ hr [6]. A synthetic image of Lutetia as it would have been observed by the OSIRIS narrow angle camera is shown on Fig. 2. Photometric observations suggest that Lutetia has a non-convex shape and that its surface is probably inhomogeneous [1]. This seems to be confirmed by recent visible spectroscopic observations, which exhibit surface variations of the spectral slope between 0.6 and 0.7 μm [10]. Its surface is probably at least partially covered by fine-grained (< 20 μm) regolith [1].

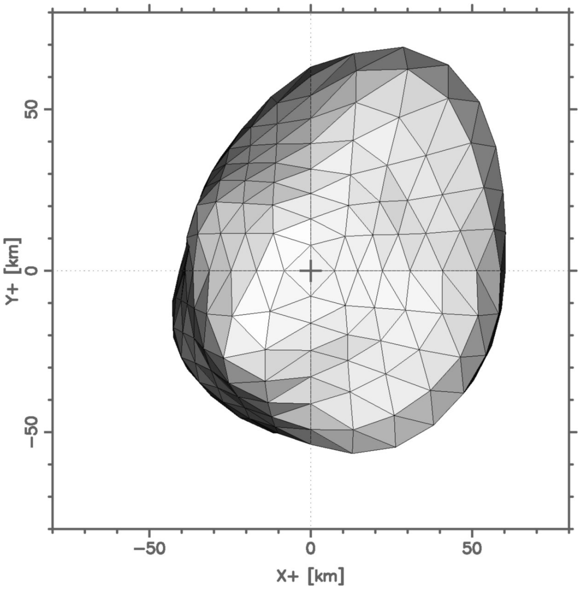

Figure 1: Pre-flyby shape model of asteroid 21 Lutetia deduced from light curves and adaptive optics observations [6, 5].

A total of 460 images will be acquired by OSIRIS during the flyby, with a minimum pixel scale of 64 m at closest approach (hereafter "CA") with the narrow angle camera. Several filters will be used, covering a wavelength range from the far UV (0.25 μm) to the end of the visible spectrum (1.0 μm). The phase angle will go through $11° - 0° - 160°$, reaching opposition 18 min before closest approach.

We will present at this conference a preliminary analysis of the shape and physical properties of Lutetia deduced from a set of images acquired by the OSIRIS narrow angle (NAC) and wide angle (WAC) cameras.

2. Calculation of the shape model

Several methods will be combined to retrieve the shape of the asteroid. Most of them have already been imple-

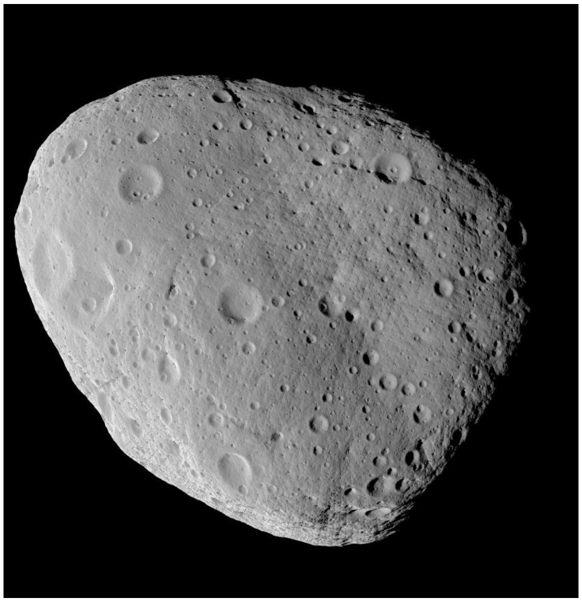

Figure 2: Synthetic image of asteroid 21 Lutetia just before closest approach. The image is based on the pre-flyby shape model of Fig. 1 modified to include a random fractal topography and a crater distribution.

mented to retrieve the shape of asteroid 2867 Steins from the OSIRIS images acquired during its flyby on 5 September 2008 [8].

We will use the so-called "limb method" to retrieve a shape model from limb profiles extracted from the images. This method will provide us with a first model without concavities. It will also yield the pointing of the camera and the geometric parameters of the scene. Control points calculated by matching points of interest on several images by stereoscopy will then be used to deform this model [2] and to create a new model with concavities.

Starting from this second model, a stereophotoclinometry method based on the selection of "maplets" [7] will allow calculating the topography of the surface. The coordinates of the center of the maplets in the body-fixed frame will be calculated by stereoscopy after co-registering the images included in the analysis. The topography around the maplets will then be determined by photoclinometry. Finally, the topography of the maplets will be combined into a global topographic model.

Due to the high inclination of its pole, only the northern hemisphere of Lutetia will be imaged during the flyby. The unobserved area of the asteroid will be constrained by a combination of adaptive optics contours and light curves photometric measurements [4, 5, 9].

3. Physical properties and topography

Using the shape model, we will calculate the bulk physical properties of the asteroid: surface, volume, relative values of the moments of inertia and gravity field [11]. The aim of the volume determination is the measurement of the density using the mass derived by the Rosetta radio science experiment. The final shape solution of section 2 will also provide us with a refined determination of the direction of the rotational axis of the asteroid.

Maps of the "local slopes" – defined as the angle between the local acceleration and the normal to the surface – and of the gravitational heights will be created. Together with the topographic model, these maps will be used to perform a preliminary analysis of the most prominent topographic features identified on the surface of Lutetia.

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