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A portrait of the Rosetta targets 2867 Steins and 21 Lutetia

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Abstract

2867 Steins is a high albedo asteroid belonging to the rare E-type and analogous to the aubrite meteorites. It was visited by the Rosetta spacecraft on 5 September 2008. 21 Lutetia is a moderate albedo asteroid that will be flied-by by Rosetta on 10 July 2010. Several observational campaigns from ground based and space telescopes were devoted to the characterization of the physical properties of these two asteroids in preparation and optimization of the Rosetta encounters. The main results from these observations will be summarized together with a comparison with the Rosetta's data.

1. Introduction

Rosetta is the cornerstone mission of ESA devoted to the study of minor bodies with the aim to investigate the origin of the Solar System. A launch postponement in 2003 caused the redefinition of the Rosetta orbit and of the mission targets. Rosetta was successfully launched on March 2004 versus the comet 67P/Churyumov-Gerasimenko, that will be reached on 2014. During its journey, two fly-bys with asteroids 2867 Steins and 21 Lutetia, on September 2008 and July 2010 respectively, were foreseen.
Observational campaigns devoted to the physical characterization of Rosetta targets were important both in the optimisation of the encounter trajectory and planning of science operations, and in the calibration, analysis and interpretation of the data acquired by the instruments onboard the Rosetta spacecraft.

2. Results from several observational campaigns

2.1 2867 Steins

Steins spectrum in the visible and near infrared range was firstly obtained by Barucci et al. [1] and successively investigated by several authors. The asteroid shows a spectral behaviour similar to that of E-type, and in particular of the E[II] subgroup, and to the aubrite meteorites. The spectrum shows a peculiar strong feature centered at about 0.49 μm, probably due to sulfide such as oldhamite, sometimes a weaker feature at about 0.96 μm, and a flat and featureless behavior beyond 1 μm [1, 2, 3]. Steins shows a strong spectral similarity in the visible range with the near Earth Asteroid 3103 Eger, and Fornasier et al. [2], investigated the possibility that Steins and Eger are both remnants of an old asteroid family, the outcome of the breakup of a parent body at about 2.36 AU. The high albedo value of 0.45 determined with polarimetric observations [4] confirm the E-type classification of Steins, and its similarity to the enstatite chondrite meteorites was confirmed by the thermal emissivity spectrum obtained with the Spitzer space telescope [5]. Nevertheless, the radiometric method applied to the Spitzer data gives an albedo value of 0.34$\pm$0.06 [6], low for a typical E-type object. Steins rotational period has been determined to be 6.04681$\pm$0.00002 h. and its thermal properties are summarized by Groussin et al [7].

2.2 21 Lutetia

21 Lutetia has been extensively study in the last 30 years, in particularly since it was selected as a target of the Rosetta mission, but the nature of this asteroid is still controversial. If fact on the basis of the visible colors and moderate albedo values (0.19-0.22) obtained with radiometric measurements, it was classified as a metallic M type asteroid. Nevertheless, its infrared spectrum and the thermal emissivity obtained with the Spitzer space telescope shows a clear analogy to carbonaceous chondrite meteorites [5]. We report in this presentation a review on the knowledge of Lutetia physical properties and in particular the results recently obtained on BVRI photometry, spectroscopy and polarimetry.

The spectral data are presented in Fig. 1. Three visible spectra measured on Nov 15/16 at different rotation phases show noticeably different shapes. In

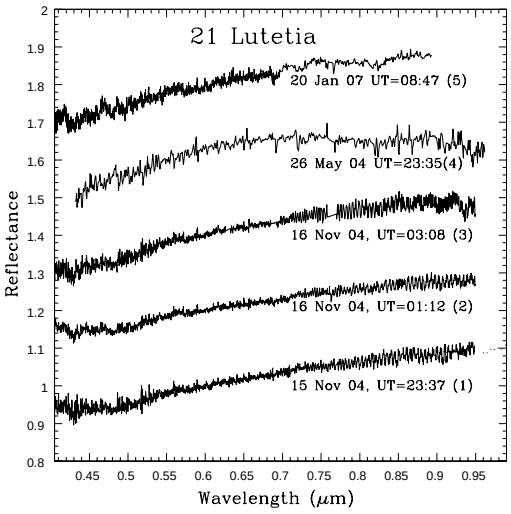

Figure 1: Visible spectra of 21 Lutetia

two spectra a broad band at 0.45-0.55 μm (1 and 2), is clearly visible, while in the spectrum close to the lightcurve maximum (3) it is less evident. A faint 0.43 μm feature, possibly associated to acqueous alteration products, is seen in all the spectra. The near-infrared spectrum measured on Nov 18, 2004 is flat, featureless within the noise of the data and with a small negative slope. Comparing the spectra with literature data, the features and spectral behaviour change with Lutetia's rotation, indicating that its surface composition is probably heterogeneous.

The lightcurves obtained in 2004 and 2008-2009 correspond to observations near the pole-on direction of lutetia and they exibit an irregular behaviour with one pair of extrema. The phase function built using new and literature data gives an absolute magnitude H=7.20$\pm$0.01, G=0.12$\pm$0.01 in the HG fit, an opposition effect amplitude of 0.36 mag and a slope phase coefficient of 0.034$\pm$0.001 $mag/^o$, values consistent with a moderate-albedo surface [8]. New polarimetric data together with literature ones gives a polarimetric slope of 0.131$\pm$0.009 $\%/^o$ and a geometric albedo of 0.16$\pm$0.02 using the calibration based on IRAS albedos. The most interesting polarimetric characteristic of Lutetia is its wide branch of negative polarization with a large inversion angle. This may imply that at least part of Lutetia's surface is covered by regolith composed of particles with a mean grain size smaller than 20 μm. Both spectral and polarimetric observations indicate that Lutetia's surface properties are quite different from those of most asteroids studied so far.The closest meteorite analogues of Lutetia's surface composition are particular types of carbonaceous chondrites (CO, CV, CH). It can not be excluded that Lutetia has a specific surface composition that is not representative among studied meteorites or has a mixed mineralogy, e.g. due to surface contamination.

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