New results from ground-based observations of asteroid 21 Lutetia prior to the Rosetta fly-by

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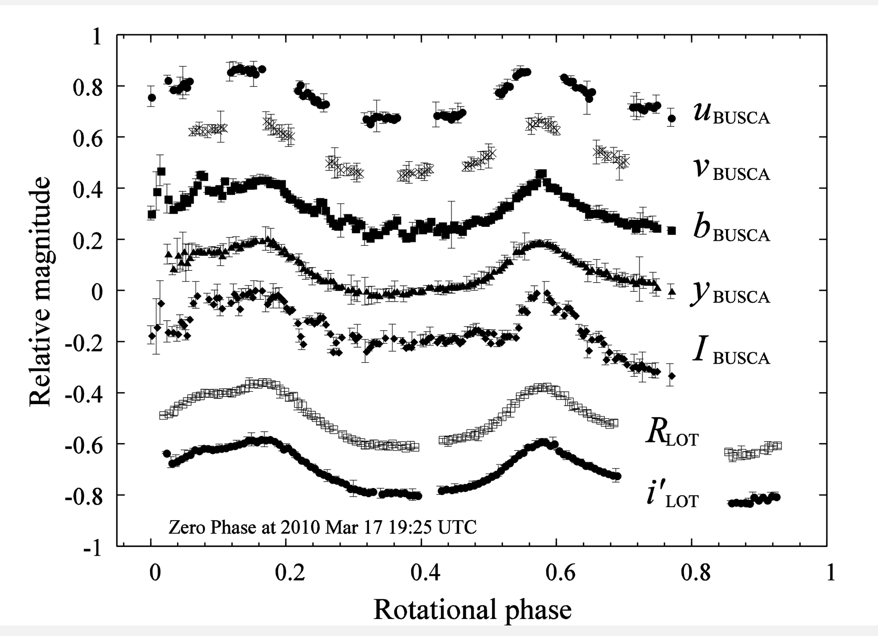
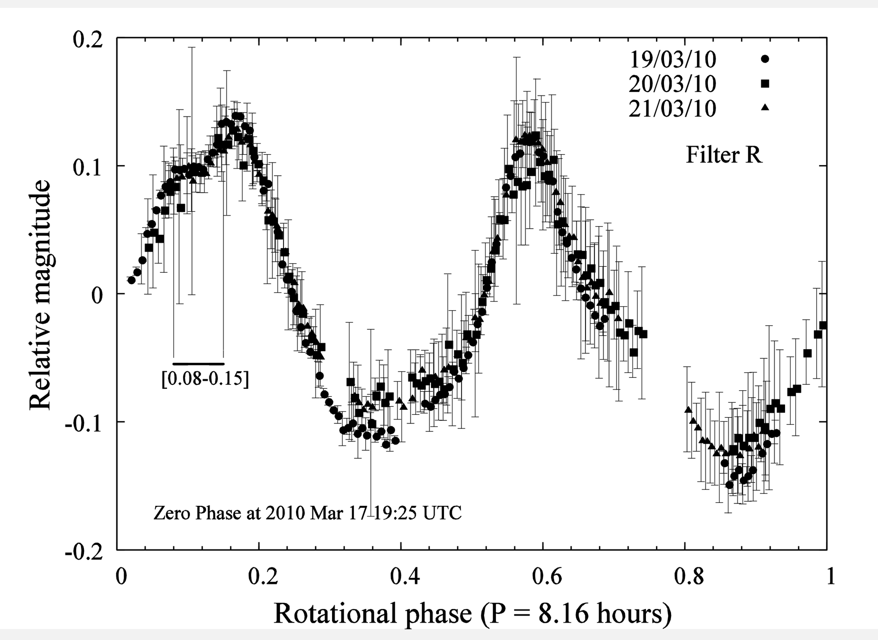
ABSTRACT

On its journey to comet 67P/Churyumov-Gerasimenko, the International Rosetta Mission (ESA) was planned to fly-by two asteroids: (2867) Steins and (21) Lutetia. This last asteroid was encountered on July 10, 2010, and data is currently being analyzed. Although classified as an M-type asteroid due to its high albedo, its reflectance spectrum in the near and mid-infrared region, suggests a primitive composition, more typical of C-type asteroids, showing also evidences of the presence of hydrated minerals. Recent results from ground based observations suggest compositional variegation and the presence of at least one significantly large crater on the surface of this asteroid. The main objective of this work is to analyse photometric and spectroscopic data of the asteroid, obtained from ground-based observations, in order to support the data taken by the spacecraft. From the photometric observations we computed the rotational period of the asteroid (P = 8.16 ± 0.08 h) and the amplitude of the its lightcurve (0.3 mag.), and both results are in good agreement with previous determinations. We also detected a brightness variation around rotational phase 0.1. We took visible and near-infrared spectra at that rotational phase, and at a different rotational phase for comparison. Differences in visible spectral slope among the spectra suggest the presence of a crater, and its shadowing effect, as the most likely cause of this variation. An absorption band centered at 0.6 µm and associated to either enstatite or phyllosilicates is also observed.

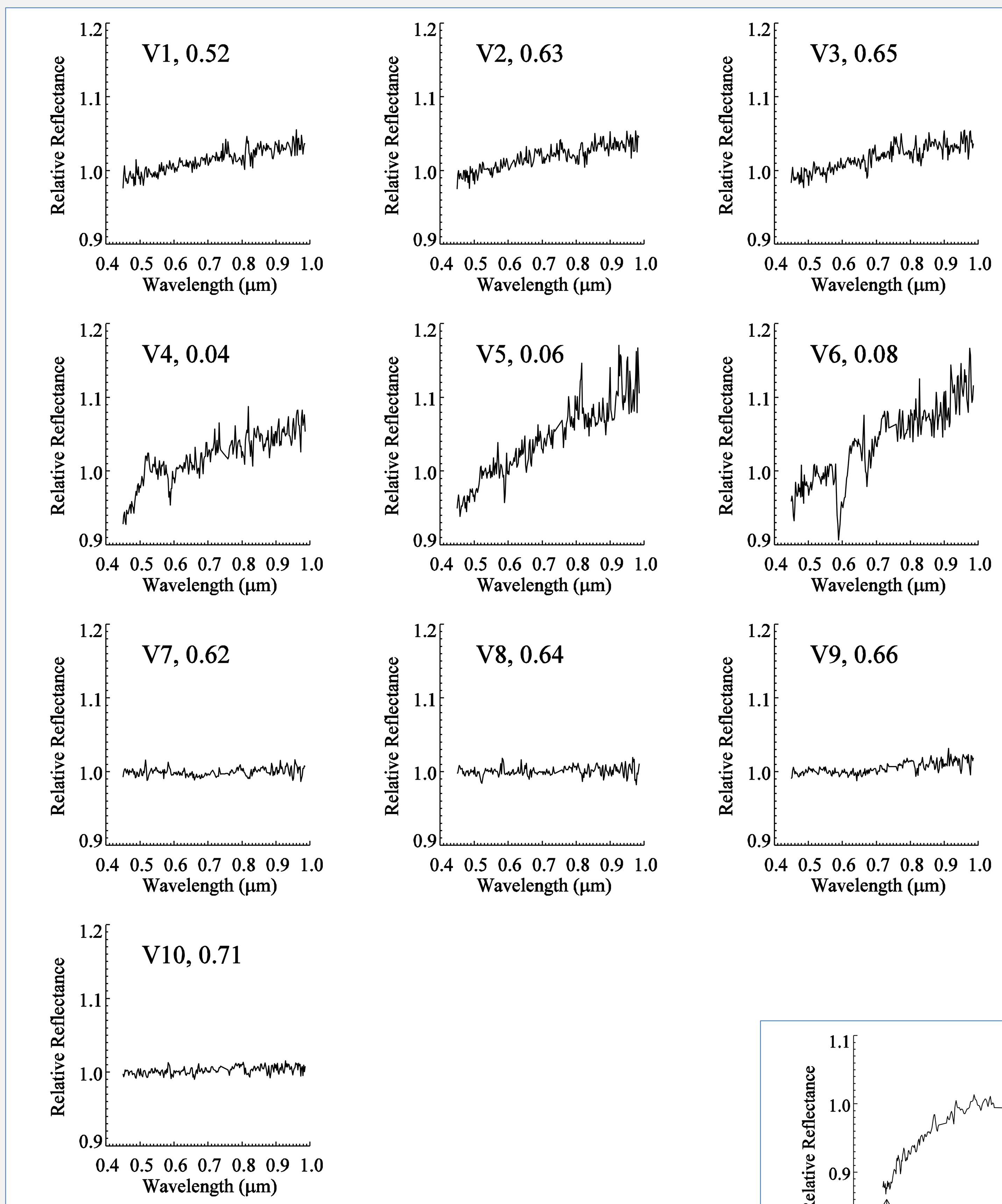
Photometric light-curves





The observations were carried out during March 2010, using both the Lulin's One-meter Telescope (LOT), managed by the Institute of Astronomy of National Central University, and the 2.2 m telescope at Calar Alto. Observations with the 2.2 m telescope were taken using the Bonn University Simultaneous CAmera (BUSCA). BUSCA is designed to perform simultaneous observations in four individual bands. For our observations, we used Strömgren filters *u, v, b, y*, and a Cousins-I filter. In the case of Lulin Observatory, we took a series of images using Cousins-*R* broadband filter and Sloan-*I'* intermediate filter. We inspected the time-resolved observations for periodicities in each filter with the Lomb technique (Lomb 1976) as implemented by Press et al. (1979). For the best quality and longer observations, that were those obtained with the Cousins-*R* filter acquired at LOT, we combined 3 nights (19, 20, 21 March) and obtained a rotational period of **8.16 ± 0.08 hrs.**

Visible and near-infrared spectra



Reflectance spectra of asteroid (21) Lutetia in the visible, and normalized to unity at 0.55 µm. The numbers correspond to the asteroid's rotational phase at which they were taken. For the visible spectra, we computed the spectral slope *S'* between 0.5 and 0.9. The difference in spectral slope at these two rotational phases can be tentatively interpreted in terms of surface inhomogeneities, associated with differences in mineralogical composition or to the effect of materials processed in different degrees and exposed in a crater area. We can see an absorption band centered at 0.58-0.60 µm on V4, V5, and V6 spectra, also been detected in the spectra of enstatite chondrites, as well as in minerals produced by aqueous alteration of silicates

Near-infrared spectra, normalized to unity at 1.6 µm. A very weak absorption feature centered around 0.80-0.85 µm, can be distinguished in IR1 and IR2 spectra. This absorption feature has been previously reported and is attributed to charge transfer transitions in oxidized iron.

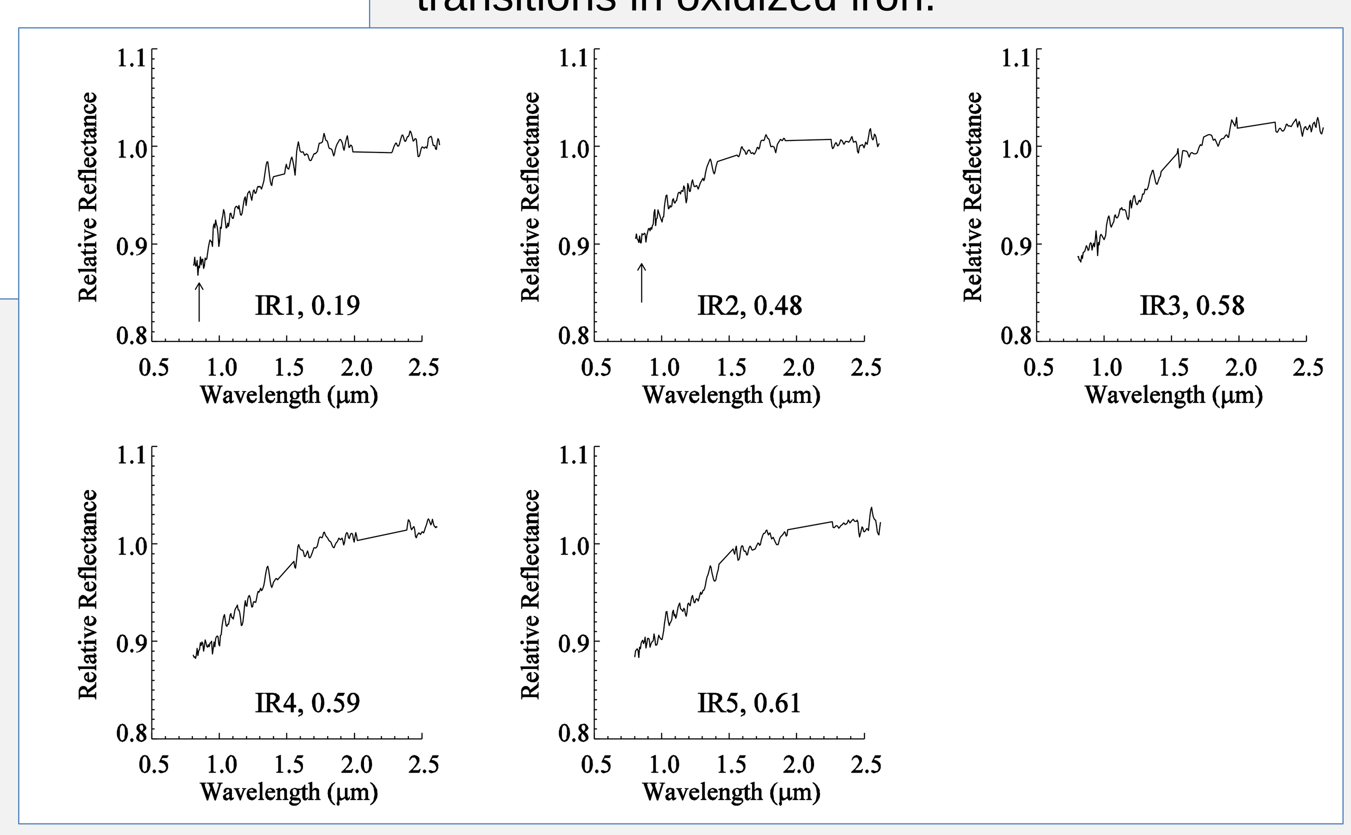


Table 1. Computed spectral slopes in the range 0.5 – 0.9 µm for visible spectra and 0.9 – 1.8 µm for near-infrared spectra

Spec. Id.	Rot. phase	S' (%/1000Å)	Spec. Id.	Rot. phase	S' (%/1000Å)
V1	0.52	1.04 ± 0.16	IR1	0.19	1.15 ± 0.10
V2	0.63	0.97 ± 0.20	IR2	0.48	0.99 ± 0.09
V3	0.65	1.06 ± 0.20	IR3	0.58	1.30 ± 0.08
V4	0.04	1.54 ± 0.28	IR4	0.59	1.28 ± 0.10
V5	0.06	3.09 ± 0.40	IR5	0.61	1.35 ± 0.10
V6	0.08	3.03 ± 0.60			
V7	0.62	0.12 ± 0.12			
V8	0.64	0.24 ± 0.20			
V9	0.66	0.43 ± 0.16			
V10	0.71	0.26 ± 0.12			

Conclusions

From the photometric light-curves on three consecutive nights, we obtained a rotational period of 8.16 ± 0.08 hours. The rotational light-curve of the asteroid presents two asymmetric minima, with a peak-to-peak amplitude of 0.25 ± 0.05 magnitudes. The obtained light-curves using different filters presented a similar behavior. We can see a small scale magnitude variation in all of them, some sort of "depression" around 0.1 rotational phase. This feature could be associated both with variations in mineralogical composition or a shadowing effect caused by the topography of the surface. Visible spectra were taken around 0.1 and 0.6 rotational phases, and spectral slope was computed in the range 0.5-0.9 µm. Spectra taken at 0.1 rotational phase presented redder slopes than the others, suggesting differences in mineralogical composition or in the level of processing of materials in a crater area. In the case of near-infrared spectra, we did not appreciate any significant variation of the spectral slope with rotational phase. Some absorption features were detected both in visible and near-infrared spectra, and were attributed to the action of aqueous alteration on minerals, namely enstatite, phyllosilicates or oxidized iron.

Image of asteroid 21 Lutetia taken with the Narrow Angle Camera of OSIRIS instrument, on-board Rosetta. The asteroid was at 3160 km from the spacecraft, near its closest approach, and the exposure time was 26 ms.