PHOTOMETRIC PROPERTIES OF THE ASTEROID 21LUTETIA FROM VIRTIS-ROSETTA OBSERVATIONS. F.Capaccioni[1], G. Filacchione[1], M.C. De Sanctis[1], F.Tosi[1], M. T. Capria[1], , E. Ammannito[1], S. Erard[2], A. Barucci[2], G. Arnold[3], [1]Istituto di Astrofisica e Planetologia Spaziali – INAF, via del Fosso del Cavaliere 100, 00133, Rome, Italy, fabrizio.capaccioni@iaps.inaf.it; [2]Laboratoire d'etudes spatiales et d'instrumentation en astrophysique (LESIA), Observatoire de Paris, CNRS, UniversitéPierre et Marie Curie, UniversitéParis-Diderot, 92195Meudon, France,[3]Institute of Planetary Research, Deutsches Zentrum für Luft- und Raumfahrt (DLR), 12489 Berlin, Germany.

Introduction: The 10th of July 2010 the Rosetta spacecraft was directed to a fly-by with the main belt asteroid 21 Lutetia. Rosetta is the planetary cornerstone mission of the ESA's program Horizon 2000 devoted to the study of a primitive body: the periodic comet 67P/Churyumov-Gerasimenko [1]. Rosetta carries onboard the VIRTIS (Visible, InfraRed, and Thermal Imaging Spectrometer) instrument which is an imaging and high-spectral resolution spectrometer covering the spectral interval 0.25-5.0 µm [2].

Lutetia is a large sized asteroids of 126x103x95km with a very high density (3.4 ± 0.3 g/cm^3); its ancient surface age (determined from crater counting) coupled with its complex geology and high density suggest that Lutetia is most likely a primordial planetesimal [3]. This was also confirmed by the spectroscopic observations performed by the VIRTIS instrument [4], which have shown no absorption features, of either silicates or hydrated minerals, see Fig. 1. No spectral signatures of surface alteration, resulting from space weathering, were observed; when compared to meteorites available on ground the Lutetia surface seems to be composed of chondritic materials of enstatitic or carbonaceous origin, dominated by iron-poor minerals that have not suffered aqueous alteration [4]. Analysis of the normalized spectral variation across the observed surface at highest resolution shows a remarkable uniformity of the surface spectral properties, displaying a maximum fluctuation of 3%. This implies that any albedo variation would be related to regolith transport and/or sorting processes rather than compositional variation.

A more detailed analysis carried out using OSIRIS images has pointed out color variations in the Baetica Region which can be correlated to surface variegations induced by either changes in the surface composition or grain size [5]. In [3] albedo variations have been already described associated to fresh (brighter) material at the crater walls and debris deposits accumulated at the bottom of the Danuvius, Gallicum and Sarnus labes of the Baetica Region. These region of freshly exposed materials were found up to 30% brighter than sourrounding areas.

Recent availability of accurate geometric information [6] allow to retrieve the illumination angles (incidence, emission and phase) for each pixel in the VIRTIS acquisitions and in all phases of the fly-by and thus to perform those photometric corrections essential to compare spectral information from different regions observed under different illumination conditions. We then set to perform this analysis to study the physical properties of the regolith as well as to verify surface variegations associated to compositional and/or textural changes.

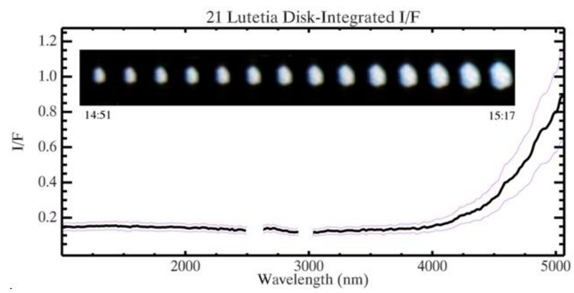

Figure 1. Lutetia mean disk integrated spectrum in the 1.0-5.0 µm spectral range and a sequence of observations of the asteroid (after [4]). The missing regions are related to instrumental artifacts in the spectrum; the rise above 4µm is due to the surface thermal emission. In light colour are shown the 1σ spectra.

Data Set: VIRTIS performed observations throughout the fly-by obtaining images and spectra of the asteroids with varying spatial resolution and illumination conditions. The observing time started 24hr before the closest approach (CA) and the full set of data is composed of data cubes obtained in different operative modes: from start to 30min before CA VIRTIS acquired hyperspectral images built using the internal scan mirror, while in the 30min around CA the instrument was operated in pushbroom mode due to the high relative speed between S/C and asteroid. Spatial resolution varied between 12km and 3km in the scan mirror phase and reached less than 1km in the pushbroom phase. Throughout this phase, VIRTIS acquired a total of more than eighteen thousand spectra. The phase angle covered is a fairly wide interval extending from 0.01° up to 140°. However, as the angular radius of the Sun at the Lutetia distance (2.72AU) is 0.1° observations at smaller phases do not improve the knowledge of the photometric properties of the object. In figure 2 are reported the mean phase curves observed for 5 infrared wavelengths. Within the selec ted wavelengths, we observed a max 10% variation of the I/F value measured at low phase angles, while the behaviour in the linear part of the phase curve does not appear to depend on the wavelength.

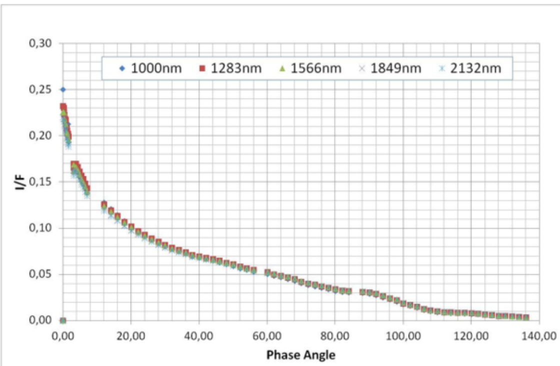

Figure 2. The Lutetia mean phase curve at various infrared wavelengths.

Photometric Function. The photometric function is composed of two terms giving a) the brightness distribution over a disk for a given phase and b) the phase function which describe the scattering as a function of the phase angle. Several approaches have been used to describe the photometric functions, here we have chosen to minimize the number of free parameters. For this reason we have selected the Lommel-Seeligeer disk function:

$$D_{LS} = \frac{2\cos i}{\cos i + \cos e}$$

depending only on incidence and emission angles and the Akimov phase function:

$$f(\alpha) = \frac{e^{-\mu_1 \alpha} + m e^{-\mu_2 \alpha}}{1 + m}$$

which contains three free parameters (α is the phase angle). μ_2 is the parameter related to the surface roughness, while m and μ_1 are correlated to the amplitude and width of the opposition effect [7]. In figure 3 is reported the fit obtained using the Akimov phase function for a single wavelength. Accuracy of the fit is consistent for the other wavelengths analysed so far (covering the full spectral range except the thermal emission region) and residual are limited to less than 10% up to 100° phase.

Forthcoming Activities: The photometric correction will be performed for all the 256 infrared spectral bands not affected by the thermal emission and a similar correction shall be performed for the 432 spectral bands in the VIS range, to generate a photometrically corrected data set. The spectral analysis in the freshly exposed areas of the Baetica region will allow to identify any wavelength dependent reflectance variation.

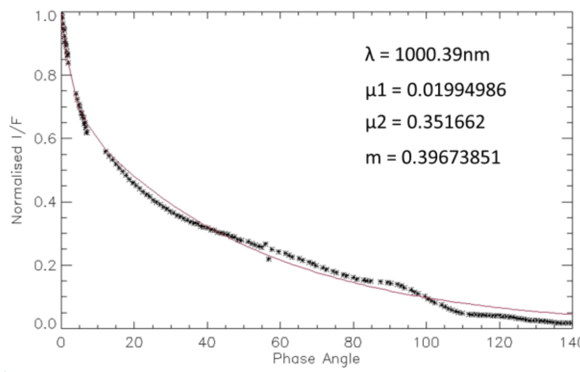

Figure 3. Fit to the phase curve covering a wide range extending from opposition to 140°.

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