A photometric model for asteroid (21) Lutetia

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(21) Lutetia has been successfully observed (July 10, 2010) by the ESA Rosetta spacecraft during its journey toward the comet 67P/Churyumov-Gerasimenko (Sierks et al. 2011, Coradini et al. 2011). All the available data show intriguing characteristics with a complex surface composition interpretation (Barucci et al. 2012). The quite high mean density estimation (3.4 ± 0.3, Pätzold et al. 2011) together with the unmatching density derived from the most probable surface compositions raise a hypothesis of (21) Lutetia having a metal core (Weiss et al 2012). The surface geology of (21) Lutetia is also highly complex with significant interactions between ancient and more recent structures (Thomas et al; 2012). The large craters and lineaments show that the object was heavily battered in the past, probably losing almost all of its crust in the process (Massironi et al 2012). If (21) Lutetia is a partially differentiated asteroid with an impact-stripped crust, a complete study of variegations might help in elucidating this event. Regions or strips of different albedo might indicate heavier- or lighter-battered surface histories. Albedo variations have been detected by Leyrat et al. (2012) in the visible wavelengths. In this work, we present a deeper analysis of the Lutetia photometric properties.

For such analysis, a full set of pipelines was developed in the Python 2.7.6 language. Images obtained by the OSIRIS cameras, NAC and WAC, were used alongside the shape model provided by L. Jorda to derive for each facet the luminance angles and the correct I/F. The pipeline takes image pixels and matches with facets on different observational conditions. Facets are iteratively fitted by a phase function and a disk function. Several phase functions were tested as Akimov (1976), Kaasalainen (Kaasalainen et al. 2003), Schroder (Schroder et al; 2013) and polynomial and were implemented; for disk function, McEwen (1991), Akimov and Minnaert (1941) were used. The method can be also applicable for any body with resolved images and precise shape model.

As a result, all phase and topological effects are removed and equigonal albedo maps (Shkuratov et al. 2011) were retrieved showing (21) Lutetia real variegations. Images close to the opposition surge, off linear regime, were handled with the Akimov or Kaasalainen functions. The obtained results will be presented and discussed, in particular maps with a distribution of opposition surge properties, such as angular width and amplitude of the surge. The opposition parameters give additional information about the grain-size distribution and grain transparency, and were only retrieved for facets with I/F of phase angles lower than 3 degrees.

References: Sierks et al., Science, Volume 334, Issue 6055, pp. 487– (2011); Coradini et al., Science, Volume 334, Issue 6055, pp. 492– (2011); Barucci et al., Planetary and Space Science, Volume 66, Issue 1, p. 23–30 (2012); Patzold et al., Science, Volume 334, Issue 6055, pp. 491– (2011); Massironi et al., Planetary and Space Science, Volume 66, Issue 1, p. 125–136 (2012); Leyrat et al., European Planetary Science Congress 2012, id. EPSC2012–534 (2012); Akimov, Soviet Astronomy, vol. 19, no. 3, 1976, p. 385–388. Translation; Kaasalainen et al., Icarus, Volume 161, Issue 1, p. 34–46 (2003); Schroder et al., Planetary and Space Science, Volume 85, p. 198–213 (2013); McEwen, Icarus, vol. 92, Aug., p. 298–311 (1991); Minnaert, Astrophysical Journal, vol. 93, p. 403–410 (1941); Shkuratov et al., Planetary and Space Science, Volume 59, Issue 13, p. 1326–1371 (2011).