EPSC Abstracts
Vol. 5, EPSC2010-55, 2010
European Planetary Science Congress 2010

Thermal properties of asteroids 21 Lutetia and 2867 Steins from Spitzer Space Telescope observations

O. Groussin (1), P. L. Lamy (1), S. Fornasier (2,3), L. Jorda (1), M. Kaasalainen (4) and B. Carry (2)
(1) Laboratoire d'Astrophysique de Marseille, Université de Provence & CNRS, Marseille, France, (2) LESIA, Observatoire de Paris, Meudon, France, (3) Université de Paris 7 Denis Diderot, Paris, France, (4) Tampere University of Technology, Tampere, Finland, (olivier.groussin@oamp.fr / Fax: +33-491661855)

Abstract

We report on Spitzer Space Telescope observations of asteroids 21 Lutetia and 2867 Steins performed on 10-11 Dec. 2005 and 22 Nov. 2005 respectively. We obtained the thermal light curve of both objects over one rotation, using the infrared spectrograph (IRS) in low-resolution mode, which covers the wavelength range 5.2-38 μm. Assuming a beaming factor (roughness) in the realistic range 0.7-1.0, we derived a thermal inertia of 0-30 $\mathrm{JK^{-1}m^{-2}s^{-1/2}}$ for Lutetia and 0-150 $\mathrm{JK^{-1}m^{-2}s^{-1/2}}$ for Steins. The thermal light curves of Lutetia and Steins are well reproduced in shape and phase by our model, but best interpreted by assuming inhomogeneities in the thermal properties of the surface, with two different regions of different roughness.

1. Introduction

The thermal properties of small bodies in the Solar System contribute extensively to the knowledge of their global physical properties and dynamical evolution. We used the Spitzer Space Telescope to observe asteroids Lutetia and Steins and derive their thermal light curve over one rotation. The thermal light curve is mainly controlled by the size and shape of the asteroid, the albedo, and the thermal properties. Any lack of knowledge of one of these parameters severely limits the interpretation of the observations. Fortunately, in the case of Lutetia and Steins, we benefit from major improvements in the knowledge of their size, shape, and albedo. The size, shape, and albedo of Lutetia were improved recently, thanks to high-angular-resolution adaptive-optics images [2, 1, 6], combined with a new analysis of the photometric observations [5, 8]. For Steins, since the Rosetta flyby, the problem of the size and shape [3] and photometric properties [7] have been solved, using OSIRIS images. The knowledge of these physical properties for Lutetia and Steins is a great advantage and offers a unique opportunity to directly constrain their thermal properties (roughness and thermal inertia).

2. Observations and data reduction

We observed asteroids Lutetia and Steins with the Spitzer Space Telescope on 10-11 Dec. 2005 and 22 Nov. 2005 respectively. We used the infrared spectrograph (IRS) in the low-resolution mode, which covers the wavelength range 5.2–38 μm. The observational sequence was repeated 14 times in order to fully sample the rotational period (∼8.2 h for Lutetia and ∼6.0 h for Steins). Observational circumstances are presented in Table 1. Data were reduced using standard procedures for IRS, as explained in detail in [4].

Table 1: Spitzer Space Telescope observations of 21 Lutetia and 2867 Steins.

Target	Date	r_h (AU)	Δ (AU)	α (deg)	λ (μm)
Lutetia	10/12/05	2.81	2.65	21.1	5-38
Steins	22/11/05	2.13	1.30	27.2	5-38

3. Thermal light curves

Fig. 1 and Fig. 2 present the thermal light curves for Lutetia and Steins, fitted by several synthetic thermal light curves. The synthetic thermal light curves are calculated with our thermal model, based on a shape model made of ∼1100 facets. As the asteroid rotates, the surface energy balance for each facet of the shape model is calculated, taking into account the flux received from the Sun, the re-radiated flux and the heat conduction into the asteroid. Since the size, shape and albedo are known for Lutetia and Steins, the only unknowns are the thermal inertia I and beaming factor η (representing roughness only: $\eta \leq 1.0$ by definition).

For Lutetia, assuming $\eta \geq 0.7$ to avoid unrealistic roughness, we obtain a thermal inertia in the range 0-30 $JK^{-1}m^{-2}s^{-1/2}$. As illustrated by Fig. 1, the fit to the data is good since the general shape of the light curve with two extrema (maximum at UT 20.5 h, then minimum at UT 22 h) followed by a plateau (at UT 24-27 h) is well reproduced, in phase and, to a lesser extend, in intensity. The remaining discrepancies for the two extrema can result from (i) uncertainties in the shape model, in particular the c (North/South) axis that is not well constrained, or (ii) surface roughness variations. In the later case, we calculate that variations of η in the range 0.68-0.88 are sufficient to explain the discrepancies.

For Steins, our analysis indicates that, depending upon η in the range 0.7-1.0, the thermal inertia is in the range 0-150 $JK^{-1}m^{-2}s^{-1/2}$. As for Lutetia, the thermal light curve is well reproduced in shape and phase by our model, but best interpreted by assuming inhomogeneities in the thermal properties of the surface, with two different regions of different roughness.

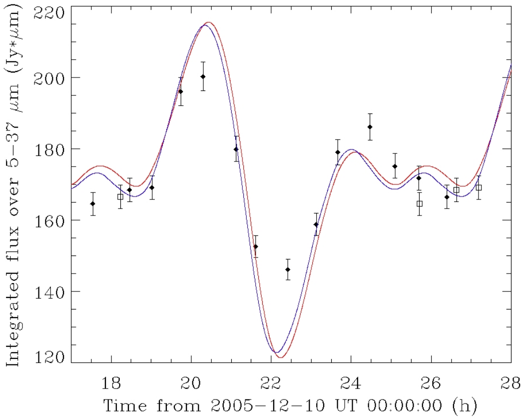

Figure 1: Thermal light curve of asteroid 21 Lutetia. The symbols correspond to the SST observations (the data points represented by squares have been phased folded). The blue line corresponds to the synthetic thermal light curve with the combination (I=0, η=0.83) while the red line corresponds to the combination (I=30 $JK^{-1}m^{-2}s^{-1/2}$, η=0.67).

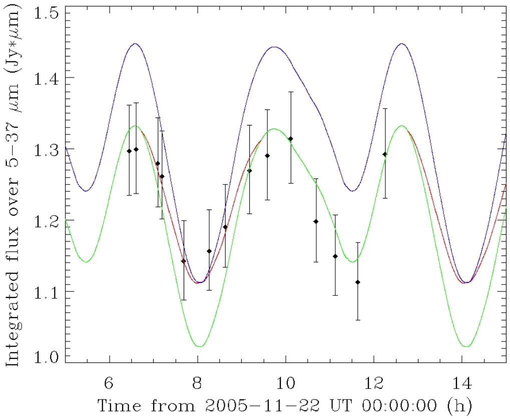

Figure 2: Thermal light curve of asteroid 2867 Steins. The symbols correspond to the SST observations. The green line corresponds to the synthetic thermal light curve with the combination (I=50 $JK^{-1}m^{-2}s^{-1/2}$, η=0.94) while the blue line corresponds to the combination (I=50 $JK^{-1}m^{-2}s^{-1/2}$, η=0.85). The red line illustrates a solution with a transition from a region dominated by a roughness corresponding to η=0.94, to a region with η=0.85.

References

[1] Carry, B., Kaasalainen, M., Leyrat, C., et al. 2010, A&A, to be submitted

[2] Drummond, J., D., Conrad, A., Merline, W., & Carry, B., 2009, DPS meeting 41, 59.07

[3] Jorda, L., et al., 2010, PSS, submitted

[4] Lamy, P., Jorda, L., Fornasier, et al. 2008, A&A 487, 1187

[5] Lamy, P., Faury, G., Jorda, L., Kassalainen, M., & Hviid, S. F., 2010, A&A, submitted

[6] Merline, W., Drummond, J., Conrad, A., et al. 2010, A&A, to be submitted

[7] Spjuth, S., et al., 2010, PSS, submitted

[8] Weaver, H. A., Feldman, P. D., Merline, W. J., et al., 2010, A&A, to be submitted