

Regolith Properties of Asteroid 21 Lutetia Constrained by Combined Data Sets of the MIRO and VIRTIS Instruments during the Rosetta Spacecraft Flyby

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Abstract

During the July 10, 2010 flyby of Asteroid 21 Lutetia by the Rosetta spacecraft, maps of surface and subsurface temperatures were derived from the VIRTIS and MIRO instruments respectively. Both data sets indicated a porous surface layer with an extremely low, lunar-like thermal inertia. However, comparisons of the VIRTIS-measured and MIRO-modelled surface temperatures revealed offsets of 10–30 K, indicative of self-heating or “beaming” effects that were not taken into account in the MIRO thermal modeling. Inclusion of a model of hemispherical craters at all scales 1 cm and larger, covering 50% of the surface, removes most of the offsets in the VIRTIS, MIRO surface temperature determinations.

1. Instrumentation

Direct dayside surface temperatures of Lutetia were retrieved from the 4.2–5.1 micron range of the VIRTIS-M channel [1]. Accuracies of less than 1 K were estimated for regions of the dayside (high SNR) unaffected by limb proximity. Subsurface temperature data from both the day and night sides of Lutetia were acquired by the MIRO continuum channels operating at 0.53 and 1.58 mm wavelength [2]. Calibration accuracies of 1 K or less were estimated for the MIRO antenna temperature measurements. Detailed descriptions of the VIRTIS and MIRO instruments can be found in [3] and [4] respectively.

2. Data analysis

The direct measurements of surface temperature by VIRTIS were obtained in “snapshot” scans five seconds apart across the asteroid in a direction approximately orthogonal to the projection of Lutetia’s spin axis onto the image plane. MIRO antenna temperatures were obtained continuously during the flyby at locations dependent on spacecraft pointing. Based on both dayside and nightside measurements, the MIRO data was used to construct a

detailed thermal and electrical property model of Lutetia’s regolith [2]. The MIRO model was then used to generate predicted surface temperature maps across the Lutetia image plane throughout the flyby. The MIRO modeled surface temperatures were then compared with VIRTIS measurements along the VIRTIS scans. Surface temperature enhancements due to self-heating effects of hemispherical craters were then added to the MIRO model predictions to examine feasible physical mechanisms that could reproduce the VIRTIS data.

3. Results

An example of the VIRTIS-MIRO surface temperature comparisons for the time of six minutes prior to closest approach is shown in figure. 1. At this time the central point of the VIRTIS scan was at 54N latitude near local noon conditions. The figure axis in the scan direction is scaled to 67 km, an early model-dependent estimate of Lutetia’s largest radial dimension. Offsets of 10–15 K (VIRTIS-measured minus MIRO-modeled) are apparent in the central regions of the scan. Larger offsets closer to the limbs are in regions of larger uncertainties in the VIRTIS measurements and increased sensitivity of the MIRO model predictions to surface slope effects. The solid lines in the figure show the effects of adding crater-induced self-heating enhancements to the MIRO model predictions. Comparison with VIRTIS data reveals that a model of 50% fractional coverage of hemispherical craters essentially removes the offsets relative to the MIRO model predictions for the wide central region of the scan. Comparison with other scans will be shown at the conference as well as extended discussion of near limb effects and details of the self-heating effects of craters.

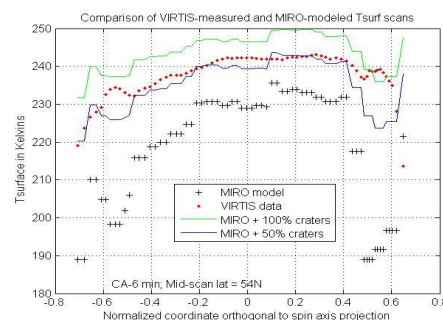


Figure 1: Comparison of VIRTIS-measured and MIRO-modeled surface temperatures across Lutetia six minutes prior to closest approach

Acknowledgements

The authors gratefully acknowledge the assistance and support of the entire VIRTIS and MIRO Project teams. We also thank the ESA Rosetta Project Team, the Rosetta Science Operations Center, the Rosetta Mission Operations Center, and NASA for their support.

References

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