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The Lutetia's and Steins' surface temperatures and surface properties

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The Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) onboard Rosetta covers the infrared range up to 5 μm using both a mapping (-M) channel and a high-spectral-resolution (-H) channel and, along with the MIRO instrument operating in the microwaves, has the capability to map surface temperatures at global and local scales. Knowledge of the surface temperature allows one to retrieve information on surface properties such as thermal conductivity, porosity, and thermal inertia.

The observation of the main belt asteroids 2678 Steins in 2008 and 21 Lutetia in 2010 has shown that the spectral region between 3.5 and 5 μm is characterised by a notable thermal emission from surface materials.

In order to retrieve a temperature map from spatially resolved VIRTIS-M data, we applied a Bayesian approach to nonlinear inversion which allows, upon selection of initial guesses for the temperature itself and the spectral emissivity, combined with the standard deviation of these unknown parameters, to iteratively and simultaneously compute surface temperature and spectral emissivity from the measured radiance. This numerical method achieves convergence in a broad range of a priori guessed values of spectral emissivity and temperature, within the instrumental noise.

The applied inversion method gives a range of temperature between 170 K and 245 K for Lutetia, and between 170 K and 230 K for Steins; in both cases direct correlation with topographic features is observed. The minimum retrievable temperature (170 K) is set by the instrument's characteristics (cutoff sensitivity and temperature of the optics), while the maximum temperature depends on some surface properties: density, thermal conductivity, and specific heat. These three quantities give the surface thermal inertia.

We have then applied a thermophysical model of the heat conduction into the asteroid's surface that allowed us to derive values for the above quantities; the model takes into account the contribution of the unresolved topography and the micro-roughness by means of a self-heating parameter (Lagerros, 1997), which enters into the definition of the thermal balance at the surface. We started with a set of values for the density, the thermal conductivity and the specific heat, compatible with a lunar regolith and optimised the resulting temperature to match the observed distribution of the temperature across the surface.

We are also in the process of producing a code to study the global 3D evolution of the surface temperature distribution of an irregularly shaped body, which would allow us to explicitly evaluate the effect of the topography (also at sub-pixel scale) on the surface temperature.

The paper shall deal with the observational data from both VIRTIS-M and VIRTIS-H, as well as with the results obtained with the abovementioned models.