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High thermal inertia areas on the surface of Vesta

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Abstract

Disk-resolved surface temperatures of Vesta have been determined from the infrared spectra measured by VIR, a visible and infrared mapping spectrometer onboard the Dawn spacecraft. The observed temperatures, together with a termophysical model, have been used to constrain the thermal properties of a large part of the surface of the asteroid. The analysis has pointed out various areas characterized by deviations with respect to the average thermal inertia. These areas are the subject of this work.

1. Introduction

Launched in 2007, the Dawn spacecraft, after one year spent orbiting Vesta, is now on its way to Ceres [1]. In the science payload, the Visible and Infrared mapping spectrometer (VIR) is devoted to the study of the mineralogical composition and thermophysical properties of Vesta's surface [2]. The instrument performs imaging spectroscopy in the overall range from the near-UV through the IR (0.25-5 micron). From VIR spectra measured longward of ~3.5 µm, surface temperatures can be retrieved by means of proper temperature-retrieval algorithms (see the Appendix in [3]).

The temperature of a surface, and in particular its variation with respect to diurnal insolation, contains information on thermal inertia and other thermal properties such as the thermal conductivity of surface materials. The VIR spectrometer is sensitive only to temperatures greater than ~180 K. While the derivation of thermal inertia would optimally involve the measurement of nighttime temperatures and as many local solar times as possible, the lower temperature limit of VIR observations has the consequence that temperature can only be quantified during a relatively narrow range of daytime local solar times. As such, a thermophysical model is required in order to constrain thermal properties.

2. Analysis of the surface thermal properties

We use a theoretical model computing surface and subsurface temperatures on a detailed shape model under a range of different assumptions and conditions. Where VIR data are available, a direct comparison can be made: when the theoretical temperature matches that one retrieved directly from VIR spectra, the assumptions on the thermal properties used in the code are assumed to correspond to reality.

The model solves the heat transport equation in a multi-layered shell with density increasing towards the center. The model depends on various input parameters, of which the most important are Bond albedo, emissivity, and thermal conductivity. Bond albedo, that is derived from geometrical albedo, is assumed to be known [4]. The subpixel roughness is taken into account and is numerically estimated.

The model has been used to map thermal inertia on most of the surface observed by Dawn. The mapping has been performed at a regional level, i.e. average thermal inertia values have been attributed to large regions. However, we know that superimposed on general trends many local variations in thermal properties can be identified on Vesta. These variations can be linked to strong albedo variations that have been observed, or to other physical and structural characteristics of the first few centimeters of the soil. These areas are easily outlined when attributing to each region its average value, because they correspond to areas in which the theoretical temperatures strongly differ from the observed ones. We have derived a preliminary list of high thermal inertia areas, corresponding to locations on the surface where temperatures are much colder than their surroundings. These locations are being analyzed in detail, taking into account their mineralogical and geological properties. Here we present the first results of this analysis.

6. Summary

While the global thermal inertia of Vesta is kknown to be very low [**ref**], the characterization of its surface in terms of regions showing peculiar thermophysical properties gives us the possibility to identify specific areas with different thermal and structural characteristics. In particular, we are analyzing those areas in which thermal inertia appears to be substantially higher than the regional average. This analysis helps us to determine the characteristics and physical properties of these areas.

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