Thermophysical Model for Binary Systems of Celestial Bodies

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Abstract

Dimorphos is the moon of a binary asteroid system. It is orbiting around a bigger asteroid called Didymos. They are classified as potential hazardous asteroids and near-Earth objects. In order to prepare the defense of the Earth in the case of a direct impact of an asteroid, the Hera mission will initiate in the years to follow an impact onto Dimorphos. The NASA is in charge of the collision with the asteroid. The ESA will study the outcomes of the impact. The spacecraft Hera will be equipped of infrared sensors, such as uncooled bolometers. Studying the evolution of the temperature on Dimorphos will help us understanding what happen after a collision. This work fits into the scheme of the simulations of thermal camera images from the spacecraft around the asteroid. This paper shows a method using asteroid thermophysical model, 3D numerical solver, NASA/NAIF SPICE and shape models.

Keywords: Thermophysical model, Binary asteroids

1. Introduction

Thermal imaging is a powerful measurement technique to characterize the physical surface of airless bodies. Recently, the analysis of thermal images from the Thermal infrared imager (TIR) on-board the Hayabusa spacecraft, revealed the highly porous nature of the C-type asteroid 162173 Ryugu [9]. The upcoming HERA mission by ESA in 2024 will be the next small body mission equipped with a TIR instrument. Compared to Hayabusa, it will have better coverage of the asteroid surface.

The target of the HERA mission is asteroid 65803 or Didymos (1996 GT), an Apollo-type near-Earth object (NEO). It is a binary asteroid: the primary body, Didymos, has a diameter of 775 m and a rotation period of 2.26 hours, whereas the secondary body, Dimorphos, has a diameter of 165 m and orbits the primary at a distance of 1.2 km in about 12 hours. The HERA observations will focus mainly on Dimorphos which is the target of NASA's Dart impactor mission. Modelling of the thermal state of the surface of Dimorphos is important to define the TIR instrument requirements, for the planning of scientific operations, to predict the environmental conditions for surface landers.

The thermophysical properties of the surface layer govern the exchange of radiative energy between the asteroid and its environment, which drives the surface and subsurface temperature. Important properties include grain size, porosity, and packing of the surface material. Measuring the temperature of the asteroid allows to estimate the thermal inertia of its surface, providing constraints on these parameters. Diurnal temperature changes are larger on fine soils (e.g. sand and highly porous rock) with lower thermal inertia, and smaller for dense rock with higher thermal inertia.

Here, we present a thermophysical model of the Dimorphos system, which includes two bodies and considers the obliquity of their spin axes. The model is used to predict surface temperature depending on the thermal inertia.

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The study will be used to set performance requirements for the HERA thermal imager. The instrument will operate in the 8-14 μ m wavelength range. It will be used for scientific analysis and to demonstrate the feasibility of using a TIR camera for GNC (Guidance, navigation and control). The main scientific goal is to determine the thermal inertia product and thus the properties of the (sub-)surface material.

2. Section 1

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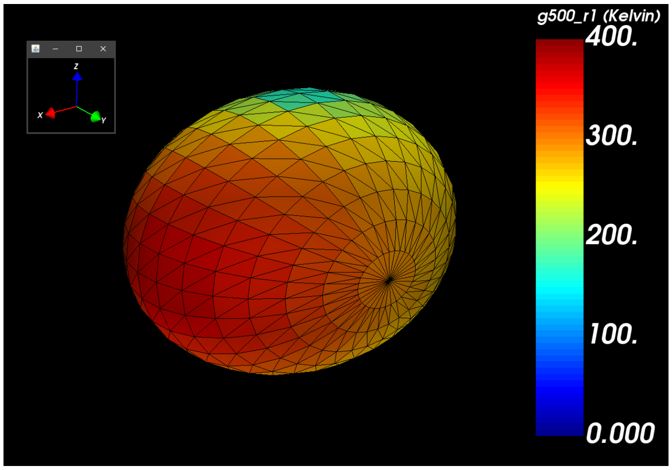

Figure 1: Some caption.

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3. Section 2

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$$E = \frac{1}{2}mv^2 \tag{1}$$

Text after.

4. Section 3

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5. Conclusion

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Acknowledgments

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References

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