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MASTER PROJECT REPORT
Simulation of thermal camera images from a spacecraft around asteroid for the HERA mission

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Abstract

Didymoon is an asteroid of the binary system Didymos. It is orbiting around a bigger asteroid called Didymain for convenience. 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 Didymoon. 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 equiped of sensors such as cameras. Studying the evolution of the temperature on Dydimoon will help us to understand what happened to after the 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.

1 The Hera mission

Cruising some 250 million kilometers around the Sun is an object first identified in 1996, by a Spacewatch survey at the University of Arizona. It was later named Didymos (Greek word for twin), after a smaller companion, Didymoon, was discovered orbiting it. Didymain and Didymoon are now both classified as potentially hazardous, near-Earth system.

Hera, named after the greek goddess of marriage, will be humanity's first probe to rendezvous with a binary asteroid system.

Hera is part of an international collaboration, alongside Nasa's DART which is due to deliver a kinetic impact Didymoon's surface, leading to to a deflection of its orbit around the bigger brother.

The mission's main objectives are to deepen our understanding of a planetary defense technique while also demonstrating numerous technologies, the likes of autonomous navigation around asteroids and gathering scientific data, further developping our understanding of asteroid compositions and structures.

Hera is set to launch in 2024, before traveling to Didymos where it will first focus on Didymoon for its study: High resolution mapping relying on Optical, radio and laser techniques.

In addition to planetary defense objectives, Hera will also carry two CubeSats on board, to be launched around the asteroid system for crucial scientific studies before touching down on their surface.

2 Current work

This paper is following the work of a previous document *Didymoon's surface thermal modeling.* The former presents a method to simulate the temperature at the surface of an asteroid. It describes in details the thermophysical model and the numerical method.

$$\begin{cases} u(x,0) = f(x), & \forall x \in [0, l_s] \\ u_x(0,t) = \dfrac{Q_{out} - Q_{in}}{k} & \forall t \geq 0 \\ u_x(ls,t) = 0, & \forall t \geq 0 \end{cases} \tag{1}$$

3 Objectives

Here are the objectives of the projet master. Next sections describe them.

4 A thermophysical model for a binary system of asteroids

In this section, we present the implementation of the mutual heating. As Didymos is a binary system of asteroid, the current thermophysical model is not enough to fully describe the temperature at the surface of the asteroid. The Hera mission focuses on the secondary object in this binary system. Its surface temperature depends also on the primary object for two main reasons: 2) the reflection of the Sun on the surface of the primary to the secondary, this phenomenon depends on the primary albedo and on its position with respect to the Sun and the secondary, and it is named the mutual direct heating, 2) the heat received from the primary itself, just as the Sun, considering it as a black body, it only depend on the distance and is called the mutual diffuse heating.

5 Advanced thermophysical model for rough surface including cratere

In this section we present the implement of the self heating. A normal at the surface of an asteroid may appear to be hidden from the direct solar flux even if it situated in the day side, for instance inside a cratere. In this scenario, it is important to take in consideration what is called the self heating of the asteroid. Due to its albedo, the surface of the asteroid relfects sunlight rays and thus, if the asteroid is not pure smooth, some reflected rays might impact another location on the asteroid.

6 Another important celestial parameter: the obliquity

This section describes the implementation of the obliquity. Explanation of the impact on the surface temperature. Description of our rotation model for the obliquity.

7 Another planetary defense mission: 2016 HO3

Description of the mission. To explain we have been requested to work for them.

8 Objectif 05

This is the fifth objectif.

9 Further works

Hera we talk about the further works.

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