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Thermal model of Didymos' secondary throughout the Asteroid Impact Mission

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Introduction

The thermal emission of the secondary in a binary asteroid system depends on the secondary's shape, size, spin vector, albedo, solar distance, surface roughness, and thermal inertia, as well as the shadowing effect and thermal radiation from the primary. All these parameters can be included in a thermal model to predict the secondary's thermal emission.

Modeling the daily temperature variation of Didymos' moon throughout the mission is important for calculating the operational temperatures of the Mascot lander and for predicting the output of the AIM thermal infrared imager and later analyzing the data.

Thermal modeling of Didymos' secondary is performed based on the current best knowledge of the physical properties of the secondary with the thermal inertia range of Γ=50–1000 J m^{-2} K^{-1} $s^{-1/2}$ [AD3: Asteroid Impact Mission: Didymos Reference Model 3.1].

Thermal model

As knowledge of the physical properties of the moon is very limited at the moment, we used a relatively simple thermal model. The model solves the one-dimensional heat conduction equation for an ellipsoidal body to provide longitude dependence. An adiabatic lower boundary is assumed, and the upper boundary condition is implemented to fulfill the conservation of energy with solar insolation depending on local coordinates, time, heliocentric distance and season. The surface is considered smooth in these preliminary calculations. Radiation from Didymos' primary is presumed negligible compared to the shadowing effect due to solar eclipses by the primary. The eclipses are included in the model under the assumption that the orbit of the moon lies in the equatorial plane of the primary with its z-axis normal to this plane. Simulations can be performed with or without eclipse conditions.

First results

Preliminary calculations have been performed for the temperature evolution of Didymos' secondary along the full orbit for a range of thermal inertia. A few examples of the results without eclipse can be found in figures 1 and 2. Including shadowing effects of the primary generally leads to lower maximum temperatures.

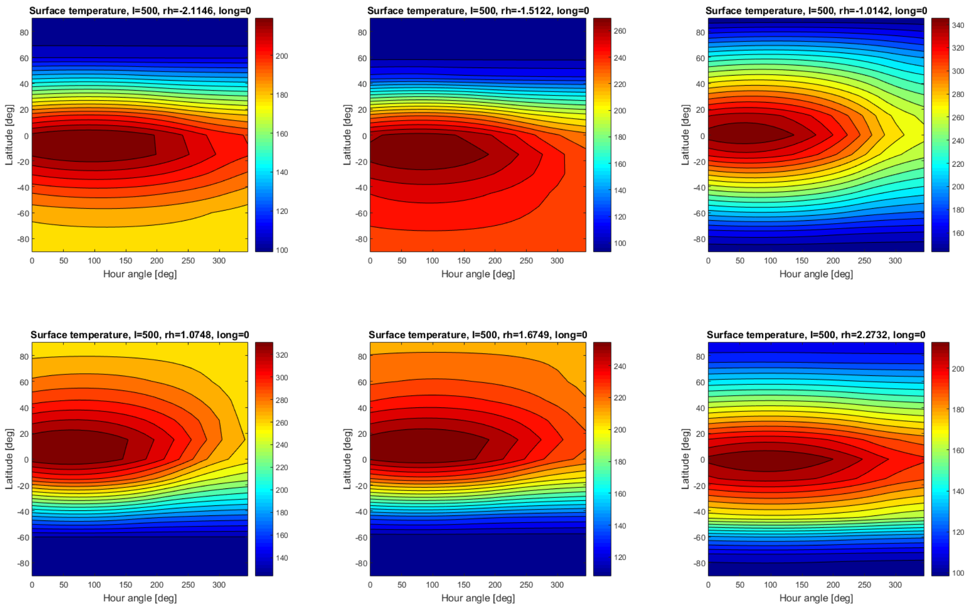

Figure 1: Contour maps of the daily surface temperature variation at longitude = 0 degree on Didymos' secondary for the case of a thermal inertia of 500 J m^{-2} K^{-1} $s^{-1/2}$. Contour maps for six different solar distances (rh, in AU) are shown. The northern winter can be seen in the first two and the northern summer in the 4th and 5th plot. The spin axis is given as 171±9 degrees [AD3]. Here, the extreme case of 162 degrees has been used.

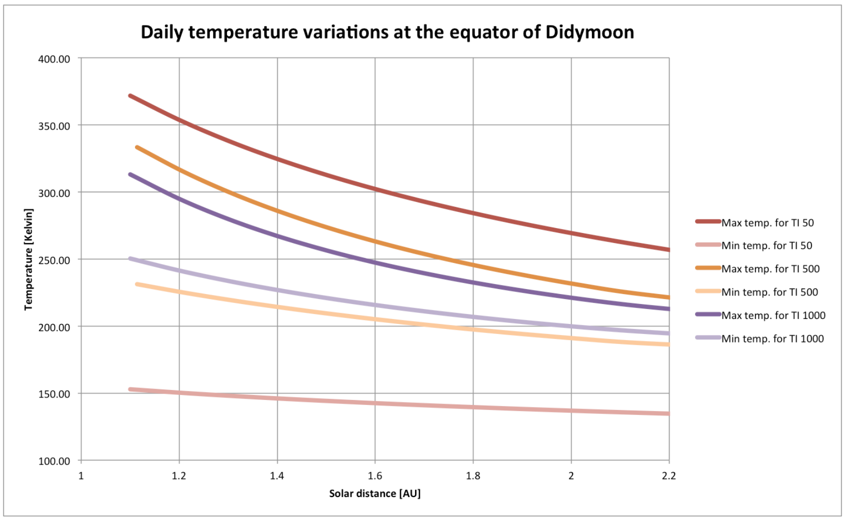

Figure 2: Daily maximum and minimum temperatures at the secondary's equator for different thermal inertia through the inward bound orbit.

Outlook

Currently, calculations are based on analytical formulations of an ellipsoid. The model however can also handle shape models with triangular and quadrilateral facets in common formats. Once available, a more detailed investigation of thermal conditions can be carried out. The model is also easily adaptable to updated physics.