APPLICATIONS OF THERMOPHYSICAL MODELLING TO NEAR EARTH ASTEROIDS.

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Introduction: Asteroids illuminated by the Sun are in constant equilibrium between the absorbed solar radiation and the thermal radiation emitted from the asteroids themselves. The thermal flux is dependant on the surface temperature distribution of the asteroid, which in turn is dependant on several factors associated with the asteroid. These include heliocentric distance, albedo, orientation of the spin vector, rotation rate, global shape, and a number of thermal properties of the surface of which the thermal inertia is most important. Simple thermal models using idealised spherical geometry and idealised assumptions of the level of thermal inertia have previously been used to determine asteroid diameters and albedos when simultaneous measurements of disk-integrated asteroid flux have been made in the visible and infrared [1]. Although successful for determining diameters and albedos of main-belt asteroids, these models however, have obvious limitations when it comes to detailed interpretations from high quality spacecraft/observational data or for the prediction of accurate asteroid thermal infrared fluxes. This is especially true for near Earth asteroids where they are known to exhibit much more irregular shapes than main-belt asteroids. Thermophysical modelling is an attempt to account for all of the physical and thermal processes involved.

Applications of a thermophysical model include analysis of spacecraft and observational infrared data, simulating spacecraft and observational measurements, and investigating the Yarkovsky effect on a target body. For example a thermophysical model coupled with data from a spatially resolved mid-infrared spectrometer onboard a spacecraft can produce surface temperature maps of an irregular shaped body (e.g. Deep Impact [2]). This could lead to a mapping of thermal inertia across the body on which the surface temperature is strongly dependant. Since the thermal inertia depends on regolith particle size and depth, degree of compaction, and exposure of solid rocks and boulders within the top few centimetres of the subsurface; it can be used to infer the presence or absence of loose material on the surface [3]. This information will be especially useful in selecting an appropriate sampling site for a future sample return mission from a near Earth asteroid. Before such a mission is launched a thermophysical model can be used to place technical constraints on the mid-infrared spectrometer required and the level of detail required from the shape model derived from imaging. The Yarkovsky diurnal and seasonal heating effects of a rotating body in space are now thought to be one of the mechanisms governing the orbital evolution of asteroids [4]. The magnitude of the Yarkovsky force for a target body can be computed by adding an additional step to the end of the thermophysical modelling process after the surface temperatures have been derived.

Presented is work in progress of a thermophysical model suitable for the applications described above. It is intended to include shape shadowing, self-radiation, and surface roughness (thermal beaming) effects. The model can readily be applied to existing shape models derived from extensive lightcurves, radar observations, and imaging from previous spacecraft encounters (e.g. see Figure 1). Examples of its application are presented and discussed.

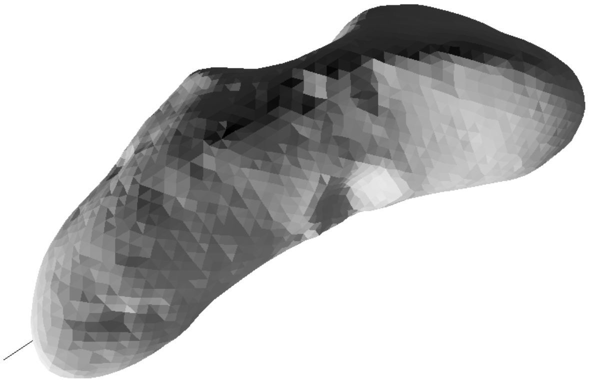

Figure 1: Surface temperature map of asteroid 433 Eros generated using a thermophysical model with an assumed thermal inertia of 40 $Jm^{-2}s^{-0.5}K^{-1}$ and the Eros shape model [5]. White facets are hotter than black facets. The minimum and maximum temperatures across the surface were 101.0 K and 386.9 K respectively.

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