THERMAL FRACTURE OF BENNU, PHAETHON, AND OTHER LOW - PERIHELION ASTEROIDS

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Introduction: Rapid temperature variations on the surface of air-less bodies, such as asteroids and comets, can cause fracturing and fragmentation of surface material [1] e.g. rocks. The same process is known to be active in hyperarid Earth deserts [2]. These temperature variations are due to the changing illumination on a rotating body, e.g. the diurnal cycles. The amplitude of these cyclic variations, and thus the efficiency of thermal cracking, are function of the heliocentric distance, rotaton period, and properties of the material [1]. Notably, the efficiency of thermal cracking is increasing for decreasing heliocentric distances [1] (see Fig. 1) and is higher for carbonaceous chondrites than ordinary chondrites (see Fig. 2).

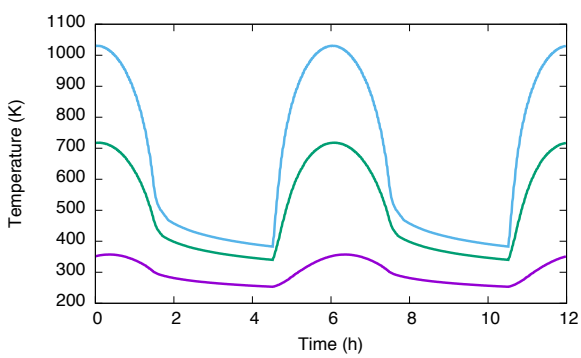

Figure 1: Temperature as a function of time for carbonaceous like asteroid [1] at distances of 1.0 (purple), 0.3 (green), and 0.15 AU (cyan) from the Sun. These asteroids have a roation period of 6 hours.

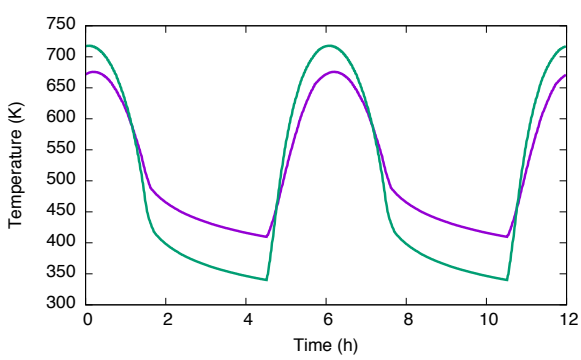

Figure 2: Temperature as a function of time for an ordinary chondrite (purple) and a carbonaceous chondrite like asteroid (green) [1] at a distances of 0.3 AU from the Sun.

Aim: Can the effects of thermal cracking be observed by e.g. the NASA's OSIRS-REx mission on the asteroid (101955) Bennu and/or by the JAXA's Hayabusa II on the asteroid (162173) Ryugu?

In addition, predictions were made [1] that small (diameter <100 m) asteroids at heliocentric distances of less than 0.3 AU could experience sufficiently fast thermal cracking to be eroded in relatively short times, certainly smaller than the dynamical lifetime of few millions of years of these asteroids. Amonst these objects, we study the peculiar case of the asteroid (3200) Phaethon, which reaches the very short perihelion distance of 0.14 AU. This asteroid is associated to the Geminids meteor stream [3]. After several attempts, recent observations confirmed the activity of Phaethon near perihelion [4]. The activity was only 10^{-4} of the Geminid stream mass, but, quoting [5], "this raises the possibility that the decay of Phaethon is a continuing process". Can thermal cracking explain the formation and the mass of the Geminids?

Methods: Here we use a well-established thermal diffusion [6], thermo-mechanical [1], and fracture mechanics [1] models in order to analyse the progressive crack growth from the early stages to final fragmentation for the surface material of asteroids having small heliocentric distances (<0.3 AU) during their orbits.

Results:

(1) Time scales for thermal fracture of rocks on Bennu and Ryugu. In particular, we use the latest shape models and spin states to study what are the regions on these bodies where rocks can fracture more rapidly due to thermal cracking.

(2) Estimates of the production of fragments for asteroids with very small perihelion distances,

(3) Efficacy of production of the Geminds by thermal craking from (3200) Phethon.

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