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Analysis of the dynamical evolution of lofted particles around (65803) Didymos asteroid

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Introduction

(65803) Didymos is a binary asteroid that orbits the Sun having a semi-major axis of 1.64 AU and is the target of the DART (NASA) and Hera (ESA) missions. The system is made up of a 780 m diameter primary body (Didymos) and a 160 m satellite (Dimorphos), orbiting the primary with a semi-major axis of 1180 m and an orbital period of 11.9 h [1]. The primary has a rotation period of 2.26 h, very close to the limit of structural stability [2] [3]. The low density estimated for Didymos, 2170 kg/m^3, shows that it is not a monolithic body but instead has a high macroporosity, typical of gravitational aggregates or *rubble-piles*. Numerical simulations show that they can be generated naturally in the aftermath of a catastrophic collision between asteroids, as a result of the gravitational interaction between the irregular fragments resulting from the collision [4]. The evolution under YORP spin-up may lead in the same case to oblate spheroidal shape asteroids with an equatorial bulge [5], commonly called *top-shapes* (eg: (162173) Ryugu [6], (101955) Bennu [7], (65803) Didymos, etc.). These bodies may rotate close to the limit of structural stability, kept together by the shear forces generated by friction between their components. The local acceleration near the equatorial regions may be directed outwards in these asteroids, allowing regolith to leave the surface [8] [9]. When this happens, particles evolve under the action of the gravitational field of the asteroid, the gravitational force of the Sun, the pressure of solar radiation, and in the case of binary asteroids, the secondary’s gravitational force intervene as well.

Methodology

In this work, we study the dynamics of the particles that are ejected from the surface of Didymos when the centrifugal acceleration is large enough to overcome local gravity. The analysis is carried out from the development of a numerical code that integrates the particles’ equation of motion in a rotating frame of reference, centered on the primary asteroid. A polyhedral shape model for Didymos is considered, formed by 1000 vertices and 1996 triangular faces, in which centers particles are placed. Particle size distribution is generated by a power law $n(r)=kr^{\alpha}$ with an index set as $\alpha=-3.5$. The environment of the asteroid is studied by computing the radial density of particles. To do this, a 3D grid is built; the surface is divided into bins of latitude and longitude and is propagated in radial bins. A process of detachment and re-entry of particles to the primary is observed, which could promote the potential formation of dust bands in the equatorial region of the asteroid. Trajectories are analyzed and the percentage of particles that re-accumulate on the secondary and the ones that completely escape the system are calculated.

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