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Dynamical and Physical Properties of 65803 Didymos, the AIDA Mission Target

A. Campo Bagatin (1), D.C. Richardson (2), K. Tsiganis (3), A. F. Cheng (4), P. Michel (5) and the AIDA Working Group 3.
(1) Universidad de Alicante, Spain (acb@ua.es / Fax: +34-965909750). (2) University of Maryland, USA. (3) Aristotle University, Thessaloniki, Greece. (4) Johns Hopkins Applied Physics Laboratory, Laurel (MD), USA. (5) Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Nice, France.

Abstract

The near-Earth asteroid (NEA) 65803 Didymos is a binary system and is the target of the proposed Asteroid Impact & Deflection Assessment (AIDA) mission, which combines an orbiter (Asteroid Impact Mission, AIM, or the reduced-scope AIM Deflection Demonstration, AIM-D^2) [1, 2] and a kinetic impactor experiment (Double Asteroid Redirection Test, DART) planned to impact the secondary of the Didymos binary system in October, 2022 [3]. The Dynamical and Physical Properties of Didymos Working Group supports the AIDA mission by addressing questions related to understanding the dynamical state of the system and inferring the physical properties of the components.

1. Dynamical properties of the Didymos system.

Didymos is an Apollo-class NEA with semimajor axis, eccentricity, and inclination (a, e, i) of (1.64 AU, 0.384, 3.4°). Using a new NEA population model [4], it likely reached its current orbit by exiting the inner main belt near or within the ν_6 resonance between 2.1–2.5 au (> 82% chance). Other possible source regions are the Hungaria asteroids (8%) and the inner/central main belt via the 3:1 mean-motion resonance with Jupiter (7%). Remote observations [5] show Didymos is spectroscopically most consistent with ordinary chondrites, with an affinity for L/LL-type meteorites. Didymos likely originated from a high-albedo family [6]; its geometric albedo, $p_V = 0.16 \pm 0.04$ [7] matches the mean albedo of the prominent Baptistina family in that zone. However, several additional family candidates may also make plausible parents (e.g., Flora, Nysa, Massalia, Lucienne). A model of the short-term binary dynamics suggests possible librations of the secondary with up to ~10-deg amplitude after the DART impact, depending on its axial ratio. Before the impact, an equilibrium orbital and rotational solution is consistent with a libration amplitude of only ~1 deg.

2. Main physical features of the Didymos system.

The diameters of the binary components are measured to be about 780 and 140 m [8]. Didymos, the primary of the system, has an estimated 2.1 g/cc bulk density (uncertainty 30%) and a possibly super-critical rotation period of 2.26 h that may imply a cohesive strength of several tens of Pa. At this rate, perturbed regolith material close to the equatorial region may go through take-off/landing cycles and cause loss of fines due to solar radiation pressure. Based on a continuum analysis [9], the internal structure would likely fail before the equatorial region. A discrete analysis [10, 11, 12] shows that a minimum of 2.5 g/cc bulk density is needed for the structure to hold without cohesion. The estimated porosity of the primary is ~35-40% so that the object is likely a gravitational aggregate. Numerical simulations show that such porosity is consistent with a largest component of the asteroid internal structure with a mass smaller than 40% of the whole asteroid mass [13]. The system may be subject to weak thermal radiation forces (BYORP) with a period drift of no greater than 1 s/yr [14]. Materials ejected from the secondary due to the DART impact are likely to reach the primary and may cause the primary to reshape due to landslide or internal deformation, changing the gravity field [15].

3. Summary

This contribution is an update of the research conducted by the working group on the Dynamical and Physical Properties of the Didymos binary system in the frame of the AIDA mission.

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