Dynamical and Physical Properties of 65803 Didymos


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65803 Didymos

The near-Earth asteroid (NEA) 65803 Didymos, a binary system, is the target of the proposed Asteroid Impact & Deflection Assessment (AIDA) mission, which combines an orbiter [1] and a kinetic impactor [2]. The current to yield stress) of the planetary surface failure

Current Dynamical State

Table 1 gives basic data on the current dynamical and rotational state of Didymos based on observations to date. The secondary is assumed to orbit in the equatorial plane of the primary. The orbit from a high-albedo family [5]; its geometric albedo, does not account for the current shape model from radar and lightcurve observations. Figure 2 shows outward accelerations. Also see [7].

Table 1: Didymos System Basic Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<tbody>
<tr>
<td>Primary Diameter</td>
<td>700 km + 10%</td>
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<tr>
<td>Secondary Diameter</td>
<td>400 km + 10%</td>
</tr>
<tr>
<td>Total System Mass</td>
<td>1.7 ± 0.2 x 10^13 kg</td>
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<tr>
<td>Component Bulk Density</td>
<td>2,100 kg m^-3</td>
</tr>
<tr>
<td>Component Separation</td>
<td>1.18 ± 0.04 km</td>
</tr>
<tr>
<td>Secondary Orbital Period</td>
<td>11.920 ± 0.004 hr</td>
</tr>
</tbody>
</table>

System dynamics

We have constructed a model for the short-term binary dynamics in which each component is represented by a rigid body component of ~1,000 Blocks that fit in the shape. The secondary is assumed to be a triaxial ellipsoid, with the ratio of axes a:b:c: varying between 1.1 and 1.5. Almost all cases appear to be stable for 300 orbits, in the absence of further tides. The orbital period and semimajor axes have very small variations (~1 m) and the eccentricity of the orbits stays < 0.10; increasing slightly with variations (~1 m) and the eccentricity of the orbit stays < 0.018, i.e., the obliquity to stay ~3° for the primary and secondary. The orbital orientation is constant to within 0.1° or 0.02°. We find that gravel-like material properties (friction angle 40°) together with a rubble-pile model of the primary made up of same-sized spheres to hold its shape.

Internal Structure

The Didymos primary is close to its final state but not limited for the least mass to remain on the surface at the equator. Weak cohesion (c < 10 Pa) may be implied, although there is sufficient uncertainty in the shape model that zero cohesion cannot yet be ruled out.

Continuum analysis

Figure 3 shows the failure mode diagram of the primary (indicating the degree of cohesion needed to maintain its shape as a function of spin period), based on a continuum analysis of the current best shape model, calculated from the internal structure and the internal bulk density. A Drucker-Prager model is used for the yield condition, and the friction angle is fixed at 35°. We find two distinct failure modes, if there is insufficient cohesion (friction). Didymos fails at a spin period of 4.0 h, longer than 3.5 h, only the equatorial region fails. Otherwise, the internal structure should fail first (Fig. 4).

Orbiting Debris

Due to the fast rotation of the primary and given the nominal physical parameters, centrifugal force may overcome gravitational force at low latitude, which allows material to go through zero-lagging-landing cycles and low losses due to radiation processes. Analysis of this effect accounting for the current shape model is ongoing to estimate the effective mass density of material in the neighborhood of the primary. These considerations apply equally well to the secondary, with the added complication that escaping material can be more elongated.

This paper has been peer-reviewed and accepted for publication in “Dynamical and Physical Properties of Didymos Working Group.”

Dynamical and Physical Properties of Didymos Working Group

The Dynamical and Physical Properties Working Group is supporting the Asteroid Impact and Deflection Assessment (AIDA) mission by addressing the following broad questions: what is the dynamical state of the Didymos system, how can the consequences of the impact be measured, and how can the physical properties of the system be inferred based on current knowledge?

Working Group Charge and Members


References