Didymos in a context of the population of binary asteroids

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Abstract

Observations of the Didymos-Dimorphos binary asteroid system revealed it to have interesting physical properties that may help us to get more understanding on formation and evolution processes of binary asteroids. We updated the Ondřejov's Binary Asteroid Parameters database with binary asteroid data obtained up to March 1, 2023. We compared the parameters of the Didymos-Dimorphos system with the data of other near-Earth, Mars-crossing and small main-belt binary asteroids. While the Didymos-Dimorphos system appears to be a typical binary in some parameters, namely, the nearly spheroidal (oblate) shape of the primary with the equatorial axis ratio close to 1, the obliquity of its mutual orbit not far from 180°, the (near-)zero eccentricity of its mutual orbit, and its total angular momentum close to critical, it is (close to being) an "end member" of the binary asteroid population in 3 other properties: the very fast primary rotation (P_1 = 2.26 h), the short orbit period (P_{orb} = 11.92 h), and the secondary's shape close to an oblate spheroid. Processes that formed the Didymos-Dimorphos system may therefore be also a kind of "extremal". It may not be straightforward to generalize them to the entire binary asteroid population.

Introduction

On September 26, 2022, NASA's Double Asteroid Redirection Test (DART) spacecraft impacted the satellite, called Dimorphos, of the binary near-Earth asteroid (65803) Didymos. It was a successful test of the Kinetic Impactor technology for diverting dangerous asteroids from collision course with Earth. Photometric, radar and spectral observations taken from 2003 up to the day of the DART impact and the images taken with the DRACO camera onboard DART led to a description of the binary system at an unprecedented level (Pravec et al., 2022; Scheirich and Pravec, 2022; Naidu et al., 2022; Daly et al., 2023; and references therein).

Fig. 1: Image of Didymos and Dimorphos taken with the DRACO instrument onboard DART (Daly et al. 2023).

Comparison with other binary asteroids

We compare the parameters of the Didymos-Dimorphos system with data that we collected for 73 near-Earth, 24 Mars-crossing, and 186 small (D_1 < 20 km) main-belt binary asteroids. (It is an update of the Binary Asteroid Parameters table from Pravec and Harris, 2007, available at https://www.asu.cas.cz/~asteroid/binastdata.htm)

Didymos is a typical binary NEA for its size

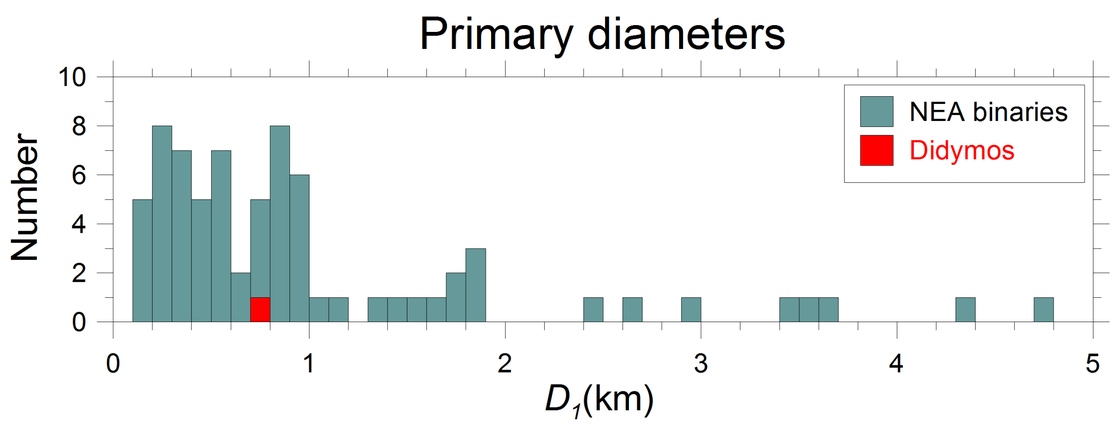

Fig. 2: Didymos's diameter is close to the median of diameters of the primaries of binary NEAs.

Didymos has a very fast rotation

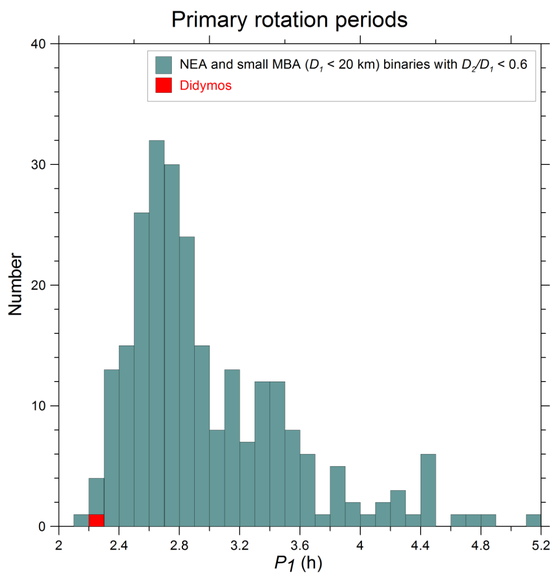

Fig. 3: Didymos's spin period (P_1 = 2.26 h) is among the shortest ones observed for NEA, MC and small MB binaries.

Dimorphos has a very short orbit period

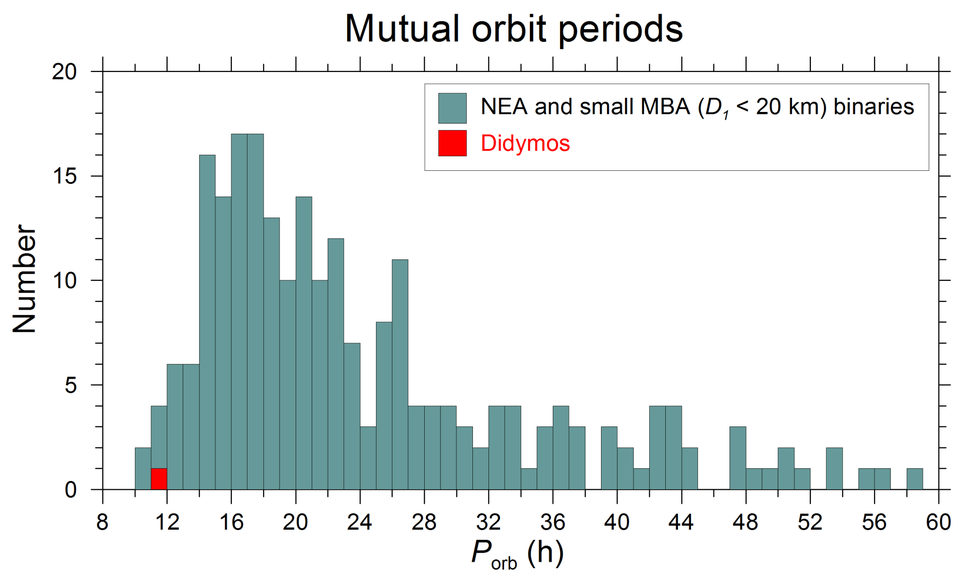

Fig. 4: Dimorphos's orbit period (P_{orb} = 11.92 h) is among the shortest ones observed for NEA, MC and small MB binaries.

Dimorphos has an extremely low equatorial elongation

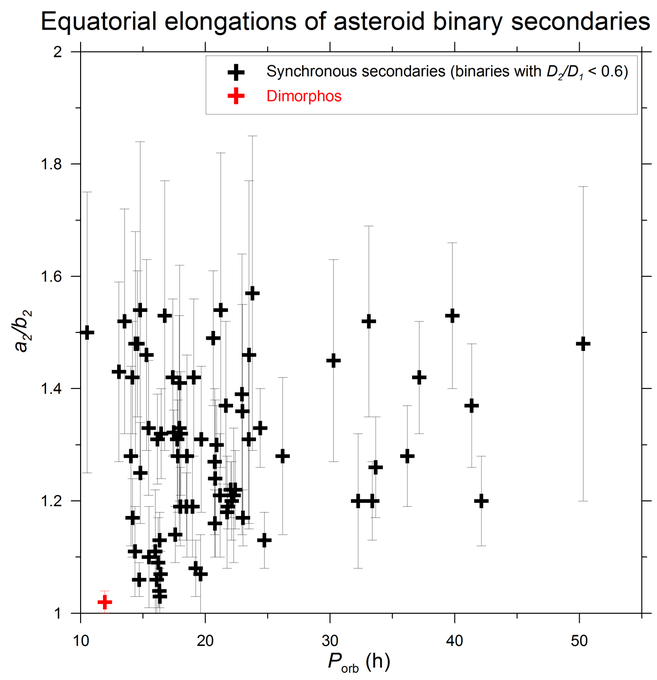

Fig. 5: Dimorphos is close to an oblate spheroid, it has an extremely low equatorial elongation (a_2/b_2 = 1.02). Caveat: There may be a bias in the a_2/b_2 data determined from remote observations against secondaries with a_2/b_2 <~ 1.05.

Possible implications

- Didymos-Dimorphos system may be a relatively **young binary** asteroid that has not evolved away from its formation state. In its subsequent evolution the tides should slow down the primary spin and expand the orbit towards a more typical system.
- It appears to be **in or very close to a BYORP-Tide equilibrium**; there was observed only a very slow contraction of the mutual orbit (Scheirich&Pravec 2022; Naidu et al. 2022).

Acknowledgement

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References

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