ROTATIONAL PROPERTIES OF BINARY ASTEROID SYSTEM (65803) DIDYMOS, TARGET OF THE DART/LICIACUBE AND HERA MISSIONS

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Introduction: Besides being objects of great scientific interest, Near-Earth Asteroids (NEAs) also represent a potential threat to human life and civilization. Awareness about the importance of "planetary defense" has progressively grown during the last decades; a review of international initiatives dedicating efforts to address the various political, scientific and technological aspects of asteroid hazard mitigation can be found in e.g. [1]. The NASA Double Asteroid Redirection Test (DART) will be the first space experiment to demonstrate asteroid impact hazard mitigation by using a kinetic impactor [2]. The DART spacecraft will be launched in mid-2021 and, on September-October 2022, will impact Dimorphos, the secondary member of the Didymos binary asteroid system, with the aim to change the mutual orbit of the two members and modify the orbit period. This change would be measured by Earth-based facilities after the impact. On-board the DART mission there will also be LICIACube, the Light Italian Cubesat for Imaging of Asteroids [3], which is a 6U cubesat space mission supported by the Italian Space Agency (ASI). It will be hosted as piggyback during the 15 months of DART interplanetary cruise, then released ten days before the DART impact and autonomously guided along its fly-by trajectory with Dimorphos, passing its Closest Approach (CA) at around 55 km some minutes after the DART impact.

Target of the DART/LICIACube mission: The target of the mission is the binary near-Earth asteroid (NEA) (65803) Didymos, an S-type asteroid similar to the most common meteorites retrieved on Earth, the ordinary chondrites, with an affinity for L/LL-type meteorites [4]. So far, we know that the Didymos system is composed by a primary object of 780 m in diameter, rotating with a period of 2.26 hours, and Dimorphos, a 165 m size satellite, orbiting at a distance of 1100 m with an orbital period of 11.91 hours [5].

Characterisation of the orbital properties of the DART/LICIACube mission target: The Italian LICIACube consortium (supported by ASI) is actively involved in the observing campaign to be performed by on-ground telescopes, with the aim to characterise at best the complex dynamical properties of the Didymos system in orbital passages *before* and *after* the impact. Some important uncertainties still remain in the determination of the orbit, which is crucial to properly tailor the entire mission. Non-gravitational forces due to anisotropic re-radiation of thermal energy in a binary asteroid system can lead to small changes in the orbit size, known as binary YORP (or BYORP, [6],[7],[8]). Presently there is ambiguity in this parameter for the Didymos system (still 3 possible solutions for a drift in mean anomaly, leading to 3 possible solutions for Dimorphos orbital phase at DART impact). Constraining BYORP will be necessary to separate the induced orbital change from any naturally-occurring change, and to allow the DART spacecraft to arrive at the Didymos system at a

time when the largest orbit period change can be applied. In addition, it is still not clear if the secondary is in synchronous rotation with the primary, and which is its relative inclination.

All these goals can be achieved by remote characterization of the system using ground-based observations, and the apparition in 2021, when Didymos will be at its brightest (V ~ 19) is the last opportunity before the mission launch (and the impact apparition). Moreover, given the favorable geometric observing conditions for 2021 (when the Earth and Sun are close to the orbital plane of the system), "mutual events", namely occultations and eclipses, can occur.

After the impact, it will be important to intensively observe the system and monitor its lightcurve, in order to measure the impact-induced change in its orbital properties (which accumulates in time) and to separate the induced orbital change from any naturally-occurring change.

Rotational properties during 2021 apparition: We will present the results of the Didymos observing campaign at Telescopio Nazionale Galileo (TNG) of Didymos system, part of the international campaign during the 2021 apparition. Lightcurves during two of the 2021 Didymos lunations (January and February), which will have favorable geometric conditions from Earth, will be used to investigate the still open questions about the unperturbed rotational properties of the system: BYORP effect, secondary rotation, and so on. In particular, a Fourier analysis of the lightcurve will allow to model the photometric variability of the system, and to estimate the contribute of the secondary (mutual events superimposed to rotation of Didymos, see Figure 1).

The determination of the whole dynamics of the binary system will be used to disentangle and properly interpret the effects of the impact on the system, thus allowing the determination of the momentum transfer enhancement parameter. The lightcurve obtained during the 2021 lunations will be promptly analysed and modelled, in order to contribute to the Level 1 DART Objective "Determine Didymos system properties" due well in advance of the DART/LICIACube launch.

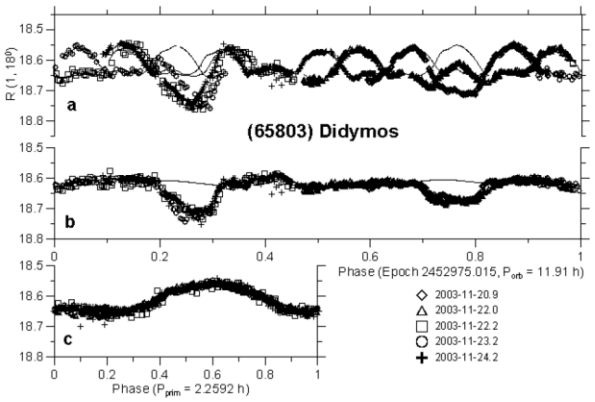

Fig. 1. From observations taken in 2003 [5]: the folded lightcurve of Didymos (panel a; phased on the Dimorphos orbital period) can be decomposed into a contribution from the rotation of Didymos (c) and a contribution due to mutual events with Dimorphos (b).

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