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Deflection / Disruption Modeling & Testing

DETERMINATION OF MOMENTUM TRANSFER TO DIMORPHOS FROM THE DART KINETIC IMPACT

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ABSTRACT

The Double Asteroid Redirection Test (DART) mission impacted Dimorphos, the secondary member of the (65803) Didymos binary asteroid, on September 26, 2022 in

order to perform the first test of asteroid deflection by kinetic impact. This deflection changed Dimorphos's orbital velocity, and the associated binary mutual orbit period change was determined from ground-based telescopic observations [1]. The size and shape of Dimorphos was determined from DART terminal approach imaging [2] and from flyby imaging by the Italian cubesat LICIACube [3], which was carried by DART and released to perform a separate flyby of Dimorphos in order to document the DART impact and image the impact ejecta plume. Dimorphos's computed volume is combined with a range of assumed density values to calculate a range of possible mass values and the associated momentum change caused by DART's impact [4]. Ejecta plume imaging by LICIACube [3] and by the Hubble Space Telescope [5] also helped determine the direction of the momentum carried by DART impact ejecta. This provides information about the three-dimensional DART impact geometry, revealing that the impact ejecta momentum vector is not collinear with the incident spacecraft momentum. The resulting momentum transfer efficiency β from the DART impact is $3.61^{+0.19}_{-0.25}$ (1σ) if Dimorphos and Didymos are assumed to have equal densities of 2,400 kg m^{-3}, and it ranges from 2.2 to 4.9 over the likely range of Dimorphos density values, 1,500 to 3,300 kg m^{-3} [4]. Extensive numerical studies of the DART impact have revealed an important non-uniqueness of the determination of β, such that many distinct sets of target material properties yield almost identical β for the DART impact conditions. LICIACube images, which resolve the ejecta plume spatial structures and study the temporal evolution, will discriminate between differences in plume structure and evolution resulting from different target physical properties, mainly strength, porosity and internal friction, thereby allowing inference of target properties. Data provided by the Hera spacecraft mission, planned to arrive at the Didymos system in 2026 [6], is anticipated to further reduce uncertainties in both β and Dimorphos's physical properties. We will present initial results for the determination of β, discuss implications for the physical properties of Dimorphos, and describe how these results inform future planetary defense efforts.

[1] C. Thomas et al., 2022 submitted
[2] T. Daly et al., 2022 submitted
[3] E. Dotto et al., 2021 *Planet. Space Sci.* **199**, 105185; Dotto et al. 2022 in preparation
[4] A. Cheng et al., 2022 submitted
[5] J-Y Li et al. 2022 submitted
[6] P. Michel *et al.,* 2022 *Planet. Sci. J.* **3** 160