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☒ **Deflection / Disruption Modeling & Testing**

# The post-DART heliocentric orbit of Didymos and implications for the effectiveness of the DART impact

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The Double Asteroid Redirection Test (DART) mission was a successful planetary defense demonstration of a kinetic impactor on Dimorphos, the satellite of binary near-Earth asteroid 63803 Didymos (Daly et al. 2023). The DART impact changed not only the orbit of the satellite Dimorphos about Didymos (Thomas et al. 2023), but also the orbit of the Didymos system about the Sun (Makadia et al. 2024). We report quantitative results of this heliocentric deflection, leading to a revised estimate of the momentum enhancement factor $\beta$ as well as an estimate of the bulk density $\rho$ of the target Dimorphos.

In the months following the DART impact, a series of stellar occultation campaigns led to a total of 18 observed occultations of the Didymos system from 2022-Oct-15 to 2023-Jan-22. These observations represent an exquisite astrometric data set, with reported errors of no more than a few milliarcseconds. Three of these observations were reported with <1 mas uncertainty, and the lowest reported uncertainty was 0.2 mas on 2023-Jan-22. With these measurements, the estimate of the Yarkovsky effect on Didymos became significantly more refined compared to the pre-impact estimates, but the effect of the DART deflection was not yet plainly discernible.

However, in 2024, observers detected three additional stellar occultations by Didymos, in May, August, and September. For reasons not yet fully understood, the May and August observations were discordant with each other, but either could fit well with the September occultation. After extensive analysis and discussion with the occultation teams, we have elected to use only the September occultation at present. The September measurement was judged the most reliable and we had no means of determining which of the other two observations should be favored, though it seems that one of them is likely reliable.

With the addition of the 2024-Sep-22 occultation, we estimate the change in velocity in a direction close to the heliocentric along-track direction to be $\Delta V = -12 \pm 3$ $\mu$m/s. This observable component of the deflection is only ~8.5° away from the system's heliocentric velocity at impact. The deflection in orthogonal directions is essentially unconstrained. Given the known circumstances of the DART impact, this deflection implies $\beta = 2.0 \pm 0.5$, which is consistent with, but somewhat lower than, previous reports (Cheng et al. 2023). A lower value of $\beta$ implies a lower bulk density $\rho$ of Dimorphos, and indeed, using the measured deflection of the Dimorphos orbit around Didymos (Naidu et al. 2024), we estimate $\rho = 1.5 \pm 0.4$ g/cm$^3$, indicating that Dimorphos is significantly under-dense with respect to Didymos.

These results should be considered preliminary. Additional opportunities for occultation observations in early 2025, if successful, will serve to clarify the status of the neglected 2024 observations and further improve the associated estimates.

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***Comments:***

*May alternatively be appropriate for the Mission Highlights session.*

*Requesting Oral.*