

NEAR-INFRARED SPECTRAL HOMOGENEITY OF THE DIDYMOS SYSTEM BEFORE AND AFTER THE DART IMPACT

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Introduction: The NASA Double Asteroid Redirection Test (DART) mission [1] became on September 26th 2022 the first humanity deliberate attempt to test the deflection of an asteroid through an impact. It crashed on the secondary member of the (65803) Didymos binary asteroid system (named Dimorphos) and proved the feasibility of the kinetic impactor technique as a planetary defense tool. The mission, together with its cubesat companion ASI Light Italian Cubesat for Imaging of Asteroids (LICIACube, [2]) was a smashing success, reaching all of its scientific goals, among which included to successfully change the orbit of its target [3,4] and to characterize the ejecta plume [5,6].

The DART mission also provided a rare opportunity: to witness on a short timescale of weeks and months the effects of asteroidal impacts on surface optical and spectroscopic properties. Asteroidal impacts are supposed to be a very frequent phenomenon in the Solar System's history [7,8]. However, due to the unpredictable nature of these events, specific studies of a natural asteroid impact have never been carried out. The DART mission provides the advantage of a precisely-predicted time and moment for the impact, which incidentally produced a big swarm of ejecta [4,6]. Obtaining new data of the Didymos system in the near-infrared (NIR) range (0.75 - 2.25 μm) was also pivotal, since the only spectrum available in this wavelength range, taken almost twenty years ago, was somewhat noisy and with shallower bands than the typical silicate asteroid [9].

New Observations: Taking advantage of the brightness of the system around the DART event, we decided to monitor Didymos and Dimorphos in the NIR to assess possible changes in their spectroscopic behavior, and look for possible inhomogeneities. Here,

we report observations carried out at Telescopio Nazionale Galileo (TNG), located on La Palma, Canary Islands, during 6 nights before and after the impact event between August and November 2022. These new data were obtained as a part of a larger collaboration among the DART/LICIACube team in order to characterize the system and monitor eventual changes induced by the DART impact.

Results: The spectral behavior of the Didymos system seems remarkably consistent in the NIR range [10]. This can be seen when comparing spectra of the system taken before and after the DART impact. All the spectra characterized in the 2022 observational window are also in good agreement with [9], observed more than 18 years before. This similarity can also be inferred when comparing the spectral slope, computed between 1.00-1.25 μm . From ground-based observations we could also infer that the Didymos system should not be very dissimilar at different rotational phases, as indicated by the substantial similarity of the spectral behavior for all the data obtained during a night pre- and post-impact. The spectral homogeneity of the system is also in agreement with the recent results from [11]. They had the chance to characterize the system right before and after the DART impact, noticing that while in the first 60 hours after the impact the spectral behavior of the system seems to change appreciably, it returns to its unaltered pre-impact status starting from September 28-29. They attribute these changes to the ejecta cloud following the impact, which likely disperse after a week.

With our ground-based data we also determined some physical properties of the ejecta. The spectral shape of the main body (which is dominated by Didymos) and the same one for the ejecta tail is substantially similar, indicating that at least Dimorphos ejecta and Didymos share a similar composition. This could confirm indirectly that Didymos and Dimorphos are roughly of the same material, as suggested by indirect considerations and dynamical models. The ESA - Hera mission, that in 2027 will characterize in greater detail Dimorphos and its cratered area, will eventually confirm the homogeneity among different rotational phases and between Didymos, Dimorphos and its ejecta.

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References: [1] Rivkin, A.S. et al. (2021) PSJ, 2, 24 [2] Dotto, E. et al. (2021) PSS, 199, 105185. [3] Thomas, C. A. et al. (2023) Nature 616, 448. [4] Cheng, A. F. et al. (2023) Nature, 616, 457. [5] Dotto, E. et al. (2023) Nature, in press [6] Li, J-Y. et al. (2023) Nature, 616, 452. [7] Moreno, F. et al. (2011) ApJ, 738, 130. [8] Ishiguro, M. et al. (2011) ApJ 740, 11. [9] De Leon, J. et al. (2006) AdSpR, 37, 178. [10] Ieva, S. et al (2024) PSJ, submitted. [11] Polishook, D. et al. (2024) PSJ, in press.