3D CHARACTERIZATION OF THE EJECTA PRODUCED BY THE DART IMPACT

Tony L. Farnham [(1)], Masatoshi Hirabayashi [(2)], J. D. Prasanna Deshapriya [(3)], Pedro H. Hasselmann [(3)], Elisabetta Dotto [(3)], Angelo Zinzi [(4)], Alessandro Rossi [(5)], Stavro Ivanovski [(6)], Megan Bruck-Syal [(7)], Andy Cheng [(8)], Elena Mazzotta Epifani [(3)], Fabio Ferrari [(9)], Igor Gai [(10)], Jianyang Li [(11)], Maurizio Pajola [(12)], Jessica M. Sunshine [(1)], K T Ramesh [(8)], Sabina Raducan [(12)], the DART Investigation Team and the LICIACube Team

[(1)] University of Maryland, College Park, MD, USA; farnham@umd.edu;
[(2)] Auburn University, Auburn, AL, USA;
[(3)] INAF-Osservatorio Astronomico di Roma, Monte Porzio Catone, Roma, Italy;
[(4)] ASI-Space Science Data Center, Roma, Italy;
[(5)] IFAC-CNR, Sesto Fiorentino, Firenze, Italy;
[(6)] INAF-Osservatorio Astronomico di Trieste, Trieste, Italy;
[(7)] Lawrence Livermore National Laboratory, Livermore, CA, USA;
[(8)] Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA;
[(9)] Politecnico di Milano - Bovisa Campus, Milano, Italy;
[(10)] Argotec, Torino, Italy;
[(11)] Planetary Science Institute, Tucson, AZ, USA;
[(12)] INAF-Astronomical Observatory of Padova, Padova, Italy;
[(12)] Space Research and Planetary Sciences, Physikalisches Institut, University of Bern, Switzerland

Keywords: *DART, Didymos, Dimorphos, Impact ejecta*

ABSTRACT

NASA's Double Asteroid Redirection Test (DART) was designed to demonstrate the potential for using a kinetic impactor to deflect the trajectory of a potentially hazardous object, and to investigate the momentum enhancement, beyond that of the spacecraft itself, that is produced by the material ejected in the impact [1]. The DART spacecraft impacted asteroid Dimorphos, the secondary component of the binary asteroid system (65803) Didymos, on 26 September 2022, changing its orbital period by 32 minutes [2,3]. The successful outcome of the experiment proved the feasibility of the kinetic impactor concept, but to fully understand how the momentum imparted by the ejecta contributed to the changes in Dimorphos' orbit, it is necessary to ascertain the net direction in which the material was expelled.

The LICIACube spacecraft, which was carried by DART and released on 11 September, altered its trajectory so as to fly by the asteroid at a distance of 58 km 167 seconds after DART's impact, thus allowing it to observe the impact and the resulting ejecta cloud [4]. During the flyby, LICIACube's LUKE camera observed from 83 to 243 seconds after impact, capturing detailed images that show details of the ejecta morphology, including a well-defined cone surrounded by intricate filamentary structures and even what appear to be individual boulders (Figure 1). The changing viewpoint over the course of these observations, produced by the spacecraft's motion, reveals the three-dimensional nature of the ejecta, and provides a means of accurately deriving the positions and velocities of the features recorded in these images.

To investigate the morphology and evolution of the ejecta, we are using techniques developed for studies of the large particles detected in the coma of comet 103P/Hartley 2 [5]. With this technique we use the parallax imparted by the spacecraft's motion to derive the locations of features that are identifiable in multiple images. With our measurements, we can map the general structure in inertial space and derive velocities of individual features in the ejecta field. We can also evaluate possible changes in velocity over the course of the observations, providing important temporal information about the evolution of the impact event. With our results we will also attempt to match the features observed in the LICIACube images to those observed in the HST, JWST and ground-based observations [6].

Our map of the ejecta field will provide critical information about the direction in which the bulk of the ejecta was emitted, which will, in turn, provide additional constraints on the momentum of the ejecta and improve our ability to determine how it contributed to the changes in Dimorphos' orbit.

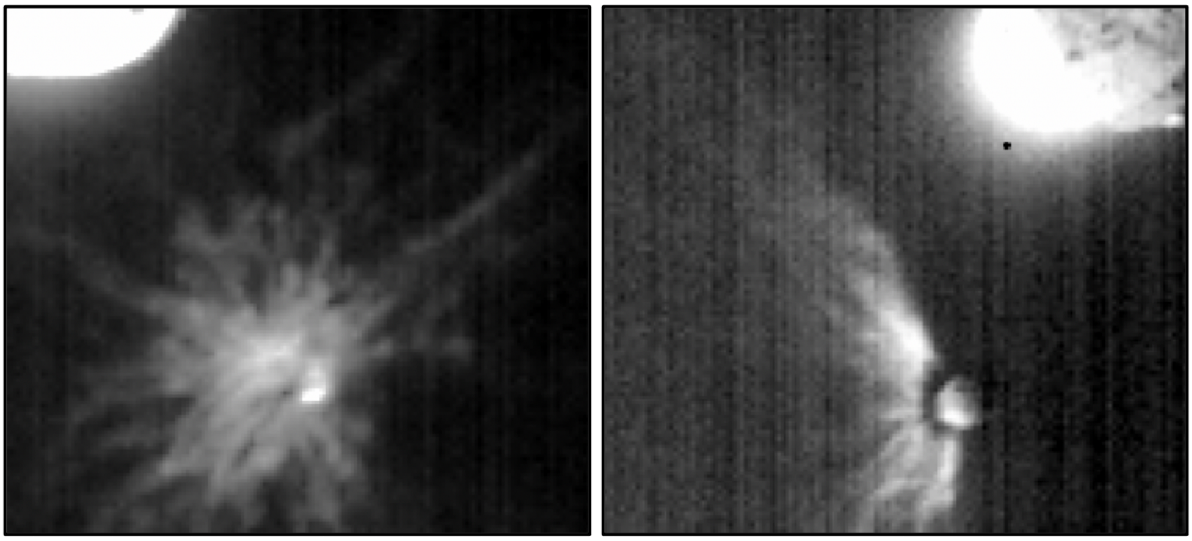

Figure 1. LUKE images of the ejecta cone arising from Dimorphos after the DART impact, showing detailed filaments and clusters of ejecta. The left panel was obtained 160 sec after impact at a range of 74 km, when the spacecraft was inside the cone and the ejecta lies in front of Dimorphos (which is partially obscured). The right panel was obtained 176 sec after impact, at a range of 71 km, showing a side-on view of the ejecta cone. The bright object at the top of each frame is Didymos in the background.

References
[1] Rivkin, A.S. et al., *PSJ*, **2:173**, (2021)
[2] Daly et al., *PSJ*, (2023) *submitted*
[3] Thomas et al., *PSJ* (2023) *submitted*
[4] Dotto, E., et al., *PSJ* (2023) *submitted*
[5] Hermalyn et al., *Icarus* **222**, 625, (2013)
[6] Li, J.-Y., et al., *PSJ* (2023) *submitted*

Comments:

Session: ***Deflection / Disruption Modeling & Testing***
Oral preferred. Will be attending in person.