CONSTRAINING THE SHAPE OF DIMORPHOS USING COMPUTER VISION ON LICIACUBE LUKE IMAGES. A. Zinzi[1,2], V. Della Corte[3], O. S. Barnouin[4], J.D.P. Deshapriya[5], P. Hasselmann[5], I. Gai[6], M. Hirabashi[7], T. Farnham[8], R. T. Daly[4], C. M. Ernst[4],E. Dotto[5], M. Amoroso[1], I. Bertini[9,3], J.R. Brucato[10], A. Capannolo[11], S. Caporali[10], M. Ceresoli[11], G. Cremonese[12], M. Dall'Ora[13], L. Gomez Casajus[6], E. Gramigna[6], S. Ieva[5], G. Impresario[1], S.L. Ivanovski[14], R. Lasagni Manghi[13], M. Lavagna[11], M. Lombardo[13], A. Lucchetti[12], E. Mazzotta Epifani[5], D. Modenini[13], M. Pajola[12], P. Palumbo[3,9], D. Perna[5], S. Pirrotta[1], G. Poggiali[10], A. Rossi[15], P. Tortora[13], F. Tusberti[12], M. Zannoni[13], G. Zanotti[11].

[1]Agenzia Spaziale Italiana, Roma, Italy (angelo.zinzi@ssdc.asi.it), [2]Space Science Data Center-ASI, Roma, Italy, [3]INAF Istituto di Astrofisica e Planetologia Spaziali, Roma, Italy, [4]Johns Hopkins Applied Physics Lab, Laurel, MD, USA, [5]INAF Osservatorio Astronomico di Roma, Monte Porzio Catone (Roma), Italy, [6]Università di Bologna, Bologna, Italy, [7]Auburn University, Auburn, AL, USA, [8]University of Maryland, College Park, MD, USA, [9]Università degli Studi di Napoli "Parthenope", Napoli, Italy, [10]INAF Osservatorio Astrofisico di Arcetri, Firenze, Italy, [11]Politecnico di Milano, Italy, [12]INAF Osservatorio Astronomico di Padova, Italy, [13]INAF Osservatorio Astronomico di Capodimonte, Napoli, Italy, [14]INAF Osservatorio Astronomico di Trieste, Italy, [15]CNR Istituto di Fisica Applicata "Nello Carrara", Sesto Fiorentino (Firenze), Italy

Introduction: The LICIACube ASI mission has been designed to acquire images of the Didymos-Dimorphos binary asteroidal system and of the plume generated by the DART-Dimorphos impact soon before and soon after this impact, happened on 26th September 2022.

In order to better witness this event, the LUKE camera, onboard LICIACube, was commanded to acquire images in a peculiar way, i.e., triplets of images at different exposure times are shoot in a very short time range with a separation ranging from 1 to 6 seconds, depending on the distance from the target.

In this way it has been possible to accurately capture details of both asteroid surfaces and plume dynamics and, differently from what the DRACO camera onboard DART, LICIACube has been allowed to take images of both hemisphere of Dimorphos [1]. This different viewing geometry makes LICIACube images an important constraint on the shape of Dimorphos.

Dimorphos shape detection: In some triplets, located soon after the flyby's closest approach, it has therefore been possible to detect the whole projected portion of Dimorphos, using images in the same triplets at different exposure times: in the short-exposure images only the illuminated hemisphere is visible, whereas in the long-exposure images, where the plume and the illuminated hemisphere are saturated, the shadowed (i.e., non illuminated) hemisphere of Dimorphos becomes visibile in contrast to the bright plume.

Exploiting some standard Computer Vision algorithms we developed an automated pipeline able to detect objects inside LUKE images, based on the expected size of Dimorphos, as seen at the known distances between LICIACube and the target.

In this way we succeded to isolate from the whole image only the Dimorphos hemisphere of interest (e.g., the illuminated one in short-exposure images and the shodowed one in the long-exposure images – Fig. 1).

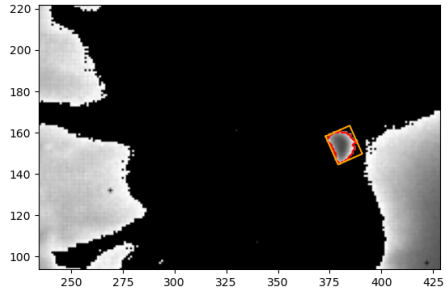

Fig. 1: An example of hemisphere detection (timestamp 1664234241, exposure time 0.035 s)

In particular, up to now in two cases we have been able to use pairs of images (short- and long-exposure ones), making it possible to quantitavely compare the results.

Preliminary results: As can be seen in Table 1, the size of the Dimorphos shadowed hemisphere is comparable between all the long-exposure images processed and it can be considered compliant to what found by DART [2].

Timestamp	Exposure Time [s]	Hemisphere area [m^2]	Shadowed [Y/N]
1664234241	0.035	5325	Y
1664234241	0.0007	3133	N
1664234242	0.05	5156	Y
1664234242	0.0003	2150	N
1664234244	0.035	5316	Y
1664234244	0.0007	2165	N

Table 1: Size of the hemisphere as computed with the CV algorithm

On the contrary, the illuminated hemisphere detected by this algorithm shows a size smaller than the

shadowed one and not in line to what expected by taking into account DART measurements.

However, by looking at the short-exposure images, a dark annulus can be seen dividing the illuminated hemisphere and the plume. It is likely that, by adding at least a portion of this annulus to the size of the illuminated hemisphere, its size will become compliant to what expected.

Conclusions and future works: Therefore we hypothesize that not all the illuminated hemisphere is really visible in the short-exposure images, as part of it is located in the shadow of the plume.

In the future we plan to improve our automatic Computer Vision algorithm, coupling it with simulated images (Fig. 2) and to process other image series, so that more robust results could be accomplished, in ordet to better determine the shape of Dimorphos and thus helping reaching all the scientific objectives of the DART-LICIACube mission.

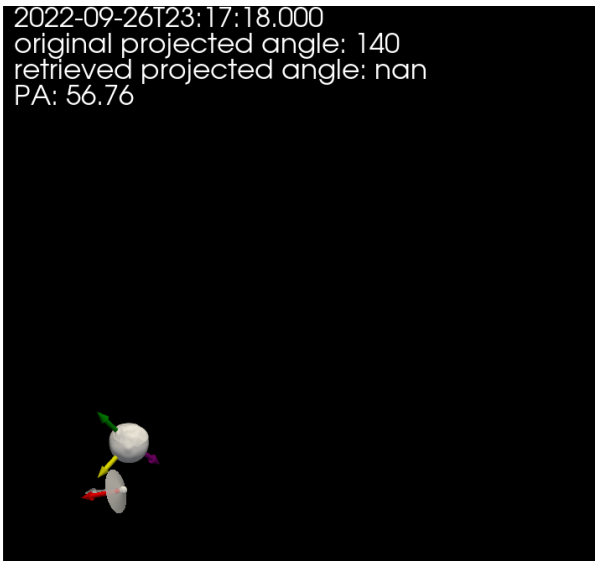

Fig. 2: Simulated image corresponding to one of the observations here considerered.

References: [1] Dotto E. et al. (2023) *Nature, In preparation*. [2] Daly, R. T. et al. (this issue)..