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

[1]Agenzia Spaziale Italiana, Roma, Italy (angelo.zinzi@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 degli Studi di Napoli "Parthenope", Napoli, Italy, [7]INAF Osservatorio Astrofisico di Arcetri, Firenze, Italy, [8]Politecnico di Milano, Italy, [9]INAF Osservatorio Astronomico di Padova, Italy, [10]INAF Osservatorio Astronomico di Capodimonte, Napoli, Italy, [11]Università di Bologna, Bologna, Italy, [12]INAF Osservatorio Astronomico di Trieste, Italy, [13]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, LUKE camera, onboard LICIACube, has been commanded to acquire images in a peculiar way, i.e., triplets of images at different exposure times is shoot in a very short time range and they were separated from each other 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].

Dimorphos shape detection: In some triplets, located soon before and 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 nightside (i.e., non illuminated) hemisphere of Dimorphos becomes visibile in contrast to the bright plume.

Using some standard Computer Vision algorithms we developed VADER (Visual Algorithm for Dimorphos Ellipsoid Recognition) a semi-automatic algorithm 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 nightside hemisphere and, by knowing the observational geometry and the major and minor visible axes, to reconstruct the whole Dimorphos' projected ellipse in the LUKE FOV by inverting the ellipse formula.

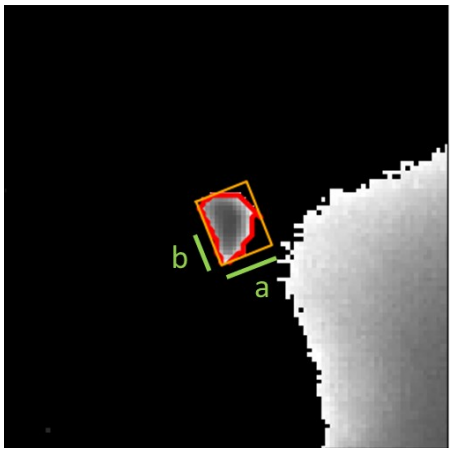

Fig. 1: An example of hemisphere detection with major (a) and minor (b) ellipse semi-axes

Once this ellipse is found for every image analysed, using the geometrical considerations explained by [2] we derived the 3D ellipsoid shape of Dimorphos.

Preliminary results: By comparing the shape of Dimorphos found with this method with that found by DART [3] it is evident (Fig. 2) that this latter is inside the possible solutions allowed by the 20% uncertainty in pixel position. However a shape more similar to what expected on the basis of observations of different secondaries and theoretical speculations [4,5] can also be reasonable for Dimorphos by looking to both hemispheres.

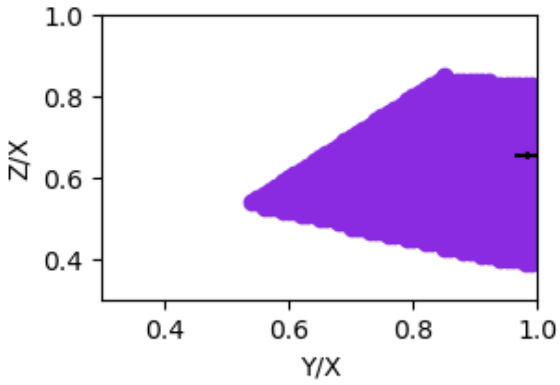

Fig. 2: Allowed solutions of ellipsoid axes ratios (purple area) compared with DART results (black point with error bars)

References: [1] Dotto E. et al. (2023) *Nature, Accepted*. [2] Binggeli, B., (1980) *Astron. Astrophys*., 82, 3 (1980) [3] Daly T. et al. (2023) *Nature*. [4] Sharma, I. (2009) *Icarus* 200. [5] Sharma, I. (2014) *Icarus* 229