PDC2023
Vienna, Austria

Dydimos and Dimorphos surface and ejecta reflectance properties through DART and LICIACube imaging.

P. H. Hasselmann(1), E. Dotto(1), J.D.P. Deshapriya(1), G. Poggiali(2,3), A. Rossi(4), I. Bertini(5), G. Zanotti(6), S. Ieva(1), S. Ivanovski(7), E. Mazzotta-Epifani(1), V. Della Corte(8), J. Sunshine(9), A. Zinzi(10,11), J-Y. Li(12), L. Kolokolova(13), D. Glenar(14,15,16), R. Lalochi(14,15,16), M. Amoroso(11), O. Barnouin(17), J.R. Brucato(2), N. Chabot(17), A. Cheng(17), A. Capannolo(18), S. Caporali(1), M. Ceresoli(6), B. Cotugno(19), G. Cremonese(20), T. R. Daly(16), M. Dall'Ora(21), V. Di Tana(19), C.M. Ernst(17), T. Farnham(9), F. Ferrari(6), I. Gai(22), G. Impresario(10), D. P. Sanchez-Lana(23), M. Lavagna(6), A. Lucchetti(20), F. Miglioretti(19), D. Modenini(22), M. Pajola(20), S. Pirrotta(10), P. Palumbo(5), D. Perna(1), S. Raducan(24), A. Rivkin(9), S.R. Schwartz(12), S. Simonetti(19), P. Tortora(22), M. Zannoni(22).

Corresponding author: pedro.hasselmann@inaf.it

1-INAF-Osservatorio Astronomico di Roma, Monte Porzio Catone, Roma, Italy;2-INAF-Osservatorio Astrofisico di Arcetri, Firenze, Italy; 3-LESIA-Observatorie de Paris PSL, Paris, France;4-IFAC-CNR, Sesto Fiorentino, Firenze, Italy;5-Università degli Studi di Napoli "Parthenope", Dip. di Scienze & Tecnologie, Centro Direzionale, Napoli, Italy;6-Politecnico di Milano, Dip. di Scienze e Tecnologie Aerospaziali, Milano, Italy;7-INAF-Osservatorio Astronomico di Trieste, Trieste, Italy; 8-INAF-Istituto di Astrofisica e Planetologia Spaziali, Roma, Italy;9-University of Maryland, Department of Astronomy, MD-USA;10-Agenzia Spaziale Italiana, Roma, Italy; 11-Space Science Data Center – ASI, Roma Italy; 12-Planetary Science Institute, University of Arizona, Tucson, AZ-USA;13-University of Maryland, College Park, MD-USA, 14-Center for Space Sciences and Technology, University of Maryland, MD-USA;15-NASA Goddard Space Flight Center, Greenbelt, MD-USA;16-Center for Research and Exploration in Space Science and Technology, NASA/GSFC, Greenbelt, MD-USA;17-Johns Hopkins University Applied Physics Laboratory, Laurel, MD-USA;18-ISAE-SUPAERO, Université de Toulouse, Toulouse, France;19-Argotec, Torino, Italy;20-INAF- Osservatorio Astronomico di Padova, Padova, Italy;21-INAF-Osservatorio Astronomico di Capodimonte, Napoli, Italy;22-Università di Bologna, Dip. di Ingegneria Industriale, Forlì, Italy; 23-CCAR, The University of Colorado, Boulder, CO-USA;24-University of Bern, Bern, Switzerland.

Keywords: *Didymos, Dimorphos, DART, LICIACube, Reflectance, Ejecta*

ABSTRACT

The NASA/DART mission successfully accomplished the first planetary defense test on the 26th September 2022 when it impacted Dimorphos, the secondary object of the (65803) Didymos binary system, and demonstrated the capabilities of the kinetic redirection technique. Dimorphos, as hit by DART with velocity of 6.1 km/s, produced a complex ejecta plume composed of filamentary streams extending roughly 10 km from the surface just hundreds of seconds after impact [1]. Before impact, DRACO imager onboard DART provided real-time images during the fast approach, unveiling Dimorphos surface in very small spatial resolution at a single phase angle of 59°. The first seconds to minutes into the event were witnessed by the LEIA and LUKE instruments of the Italian Space Agency Cubesat's LICIACube [2]. These cameras captured hundreds of images during their fly-by maneuver, with the closest approach of about 57 km. The disk-resolved data obtained has the largest phase angle coverage, ranging from 43° to 118°.

With this large phase angle coverage and target resolution, combined with ancillary data such as trajectories and shape models, it is possible to retrieve the observational geometries necessary for testing photometric surface reflectance models [3,4,5]. The mid-to-high phase angles of these images are suitable for constraining the surface roughness, the asymmetric factor between scattering lobes, and also the single-scattering albedo. Preliminary tests with the Hapke model [2] on

DRACO data using MCMC Variational Inference [6], reveal a surface with photometric properties similar to other S-type asteroids.

For the ejecta analysis, we rely on the outputs of dynamical simulations performed by LICEI from Housen & Holsapple scaling laws [7,8,9] and the optical constants and phase function from laboratory measurements of analog compositions to understand the grains size, velocity and spatial distribution from the brightness radial distribution derived through LICIACube observations. This analysis is of ultimate importance to constrain the mass and scattering properties of the ejecta and cast light to the effects of the impact into Dimorphos surface and internal structure.

Finally, the LICIACube experiment is proved to be of crucial importance to comprehend the first instants of the aftermath of the first planetary-scale kinetic redirection experiment ever conducted by man. Surface and ejecta reflectance properties allows us to constrain the scattering properties of Dimorphos' regolith through two fronts, setting important information for future planetary defense tests on same asteroid size range.

References:
[1] Dotto et al., 2023, Nature, submitted. [2] Dotto et al., 2021, PSS 199. [3] Hapke 2012, 2nd Editon, Cambridge Publisher. [4] Shkuratov et al., 2011, PSS 59. [5] Hasselmann et al., 2016, Icarus 267. [6] Kingma & Welling, 2014, AVBS, 1050, 1. [7] Rossi et al., 2022, PSJ 3, 118. [8] Zanotti, G., Lavagna, M., (2020), 71st IAC Procc. [9] Housen& Holsapple, 2011, Icar, 211, 856.

Acknowledgements: This research was supported by the Italian Space Agency (ASI) within the LICIACube project (ASI-INAF agreement AC n. 2019-31-HH.0).

****

Comments:
Preferentially oral contribution.