DART-driven ejecta cone geometry measurement from Hubble Space Telescope and LICIACube

Masatoshi Hirabayashi[1], Tony L. Farnham[2], Jasinghege Don Prasanna Deshapriya[3], Jian-Yang Li[4], Alessandro Rossi[5], Pedro H. Hasselmann[3], Elisabetta Dotto[3], Stavro L. Ivanovski[6], Olivier S. Barnouin[7], R. Terik Daly[7], Igor Gai[8], Hari Nair[7], Eric E. Palmer[4], Angelo Zinzi[9], Harrison F. Agrusa[2,10], Brent W. Barbee[11], Nancy L. Chabot[7], Andrew F. Cheng[7], Eugene G. Fahnestock[12], Alex J. Meyer[13], Andrew S. Rivkin[7], the DART Investigation Team, and the LICIACube Team

[1]Auburn University, Auburn, AL, USA, thirabayashi@auburn.edu, [2]University of Maryland, College Park, MD, USA, [3]INAF-Osservatorio Astronomico di Roma, Rome, Italy, [4]Planetary Science Institute, Tucson, AZ, USA, [5]IFAC-CNR, Sesto Fiorentino (FI), Italy, [6]INAF-Osservatorio Astronomico di Trieste, Trieste, Italy, [7]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA, [8]Università di Bologna, Bologna, Italy, [9]Agenzia Spaziale Italiana, Roma, Italy, [10]Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Nice, France, [11]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [12]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, [13]University of Colorado, Boulder, CO, USA

Summary:

The ejecta cone generated by the DART impact on Dimorphos is asymmetric.

Introduction:

The ejecta cone geometry is one of the key parameters determining the kinetic impact deflection capability. To access this, the DART team has applied a metric called the momentum enhancement factor, β, which depends on the cone orientation [1].

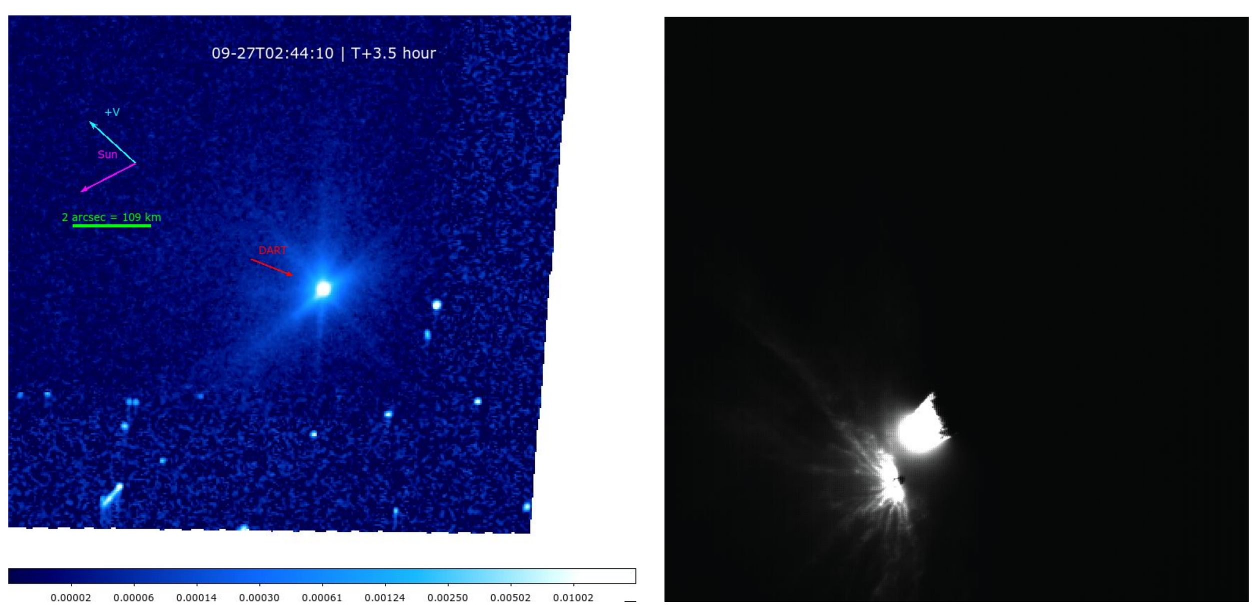

Figure 1. Images from Hubble Space Telescope (left) and LICIACube (right).

The preliminary analyses suggested multiple cone opening angle solutions, while the cone axes solutions were consistent.

1. 140° ± 4° - LICIACube images only [2]
2. 125° ± 10° - HST images only [3].

This inconsistency likely results from the asymmetric cone geometry. **A new algorithm was applied to determine an asymmetric cone using both HST and LICIACube images.**

Methodology:

An estimator was developed to determine the cone geometry using images from HST and LICIACube. The technique assumed the cone geometry to be asymmetric, i.e., a cone forming an ellipse at its intersection with a plane perpendicular to its axis. Table 1 shows the latest values and uncertainties (1σ) in J2000.

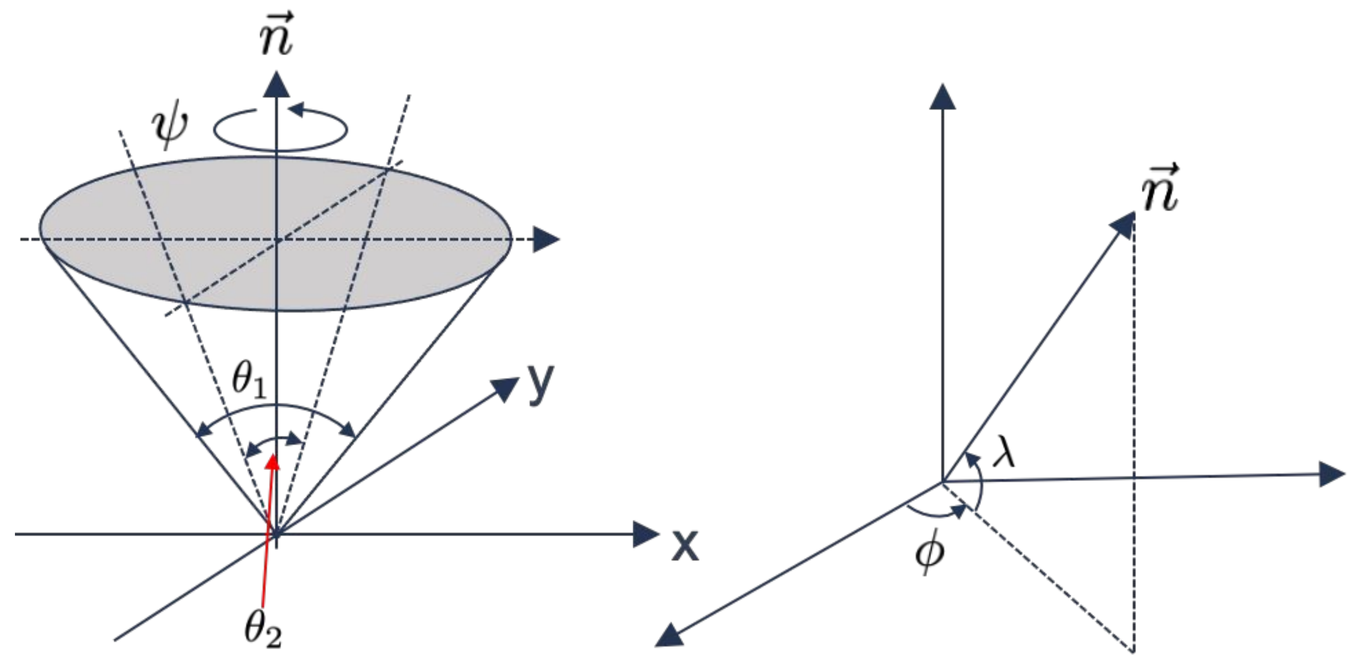

Figure 2. Cone geometry using parameters

Table 1. Cone geometry using parameters

Symbol	Description	Values in J2000
θ1	Narrow cone opening angle	91±5
θ2	Wide cone opening angle	136±10
ψ	Cone rotation angle	91±8
λ	Declination	141±3
φ	Right ascension	20±7

The values in Table 1 were derived using a Monte Carlo approach simulating the stochastic behavior of the cone geometry solutions, given the uncertainties of the cone edge orientations (120 cases in total).

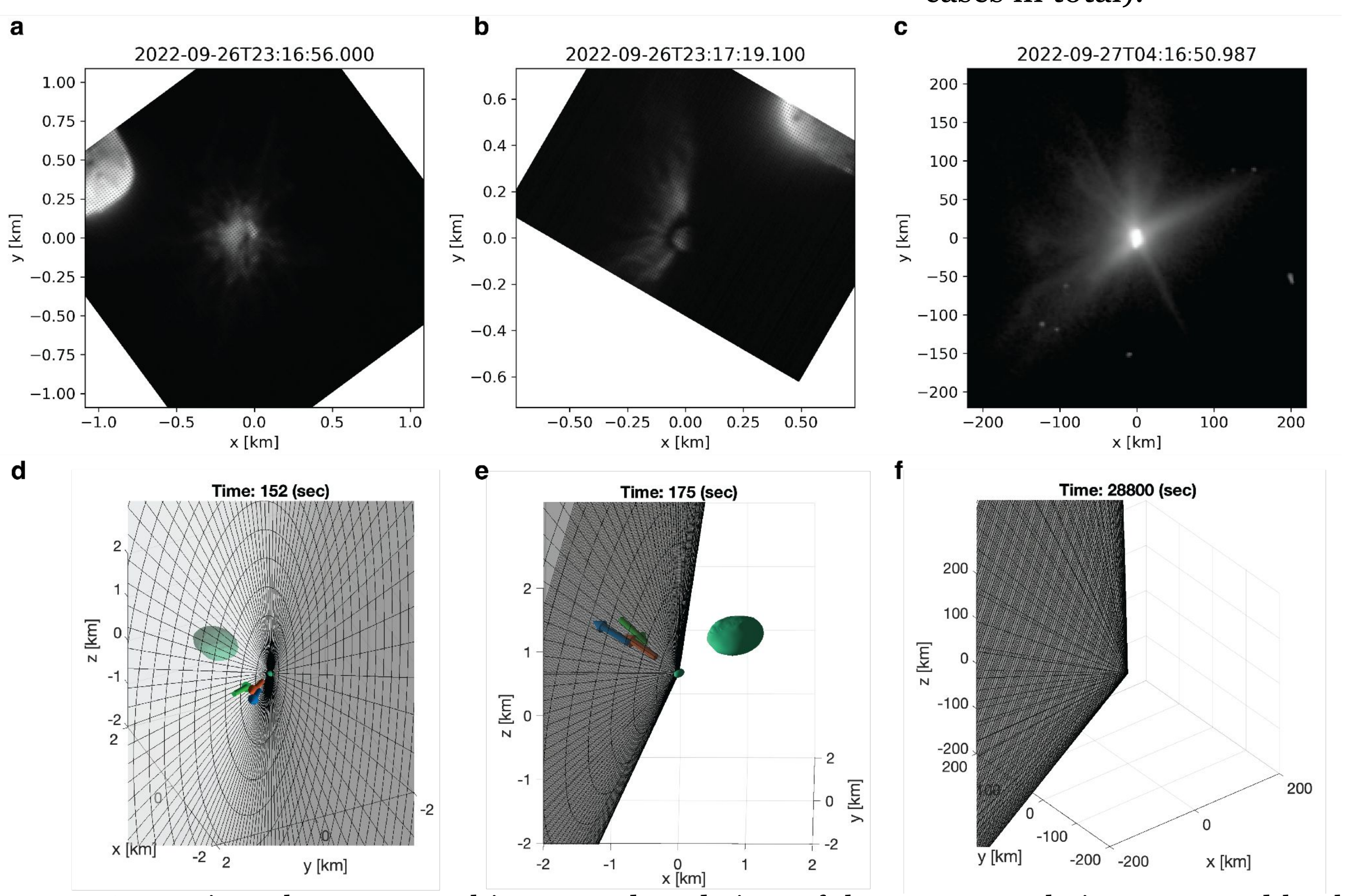

Figure 3. Comparisons between actual images and renderings of the geometry solutions generated by the estimator. Each column has the same timing. Panel pairs (a, d) and (b, e) show LICIACube's view, and pair (c, f) illustrates HST's view.

Interpretations:

As seen in Figure 3, the cone geometry was found to be asymmetric. The wider cone direction was almost similar to the N-S direction of Dimorphos. There are multiple interpretations of this asymmetric cone. First, the North-South direction has a higher curvature [4], giving a shallower ejecta cone. Second, material heterogeneity on/beneath the surface [4] caused material flows to create the asymmetric cone. Finally, the spacecraft's irregular shape [4] changed the flow fields to generate the asymmetric cone.

Reference: [1] Cheng et al. (2023), Nature, in press. [2] Dotto et al. (2023), in preparation. [3] Li et al. (2023), Nature, in press. [4] Daly et al. (2023), Nature, in press.

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