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Mass ejection by fast-spinning Didymos: orbiting dust and transference to Dimorphos

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The near-Earth binary asteroid (65803) Didymos gained significant scientific attention after the successful impact of NASA's DART mission on its secondary, Dimorphos, validating kinetic impact as a planetary defence strategy [1]. This study builds on previous analyses of particle dynamics on Didymos' surface [2]. Using updated physical parameters [3] and a high resolution shape model [4], we investigate material lift-off induced by its rapid rotation and mass transference to the secondary.

We assess the asteroid's surface stability by exploring a range of mass and asteroid extents using the reported values, along with their corresponding uncertainties. A total of 25 combinations of mass and volume values were analyzed using numerical simulations, investigating the trajectories and final states of the ejected particles. Four distinct outcomes were identified: reimpact on Didymos (ES1), particles remaining in orbit (ES2), collisions with Dimorphos (ES3), and escape from the system (ES4). Our results show that over 85% smaller particles (<5 μm radius) quickly return to Didymos, concentrating in equatorial regions, while larger particles (>5 cm radius) reach mid-latitudes or higher. Such particles could trigger surface sliding, potentially explaining mass wasting features [5, 6].

Orbiting particles form disk-like structures around Didymos, but absolute density values cannot be derived as they depend on the actual emission mass rate, and may be observationally undetectable. The densest regions are located near 600 meters from the asteroid's center. Over time, solar radiation

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pressure (SRP) drives smaller particles to form a comet-like tail in the direction opposite to the Sun. Larger particles, less affected by SRP, remain in stable orbits for up to six months. The distribution and dynamics of such particles are the outcome of complex interactions due to Didymos' irregular shape, fast rotation, and solar radiation pressure.

Material transfer to Dimorphos is also notable, with up to 12% of the largest particles colliding with its surface at ~ 0.14 m/s, comparable to its escape velocity. Most impacts occur in the trailing hemisphere of Dimorphos, following linear patterns determined by the initial trajectories of the particles.

The ESA Hera mission [7], accompanied by the Milani CubeSat carrying the VISTA instrument [8], will offer a unique opportunity to detect dust particles and volatile materials in the Didymos system. VISTA's ability to measure particles as small as 10 μm will be crucial for validating our prediction of dust production and the persistence of fine material in the system's environment. Given the short survival time of fine material, any dust detected by VISTA would support the take-off and landing processes described in this study. These findings could shed light on the dynamics of loose material on fast-rotating small bodies and the interaction between binary asteroid components, enhancing our understanding of resurfacing and orbital processes in binary asteroid systems.

References

[1] C. A. Thomas, S. P. Naidu, P. Scheirich, N. A. Moskovitz, P. Pravec, S. R. Chesley, A. S. Rivkin, D. J. Osip, T. A. Lister, L. A. M. Benner, M. Brozović, C. Contreras, N. Morrell, A. RoŻek, P. Kušnirák, K. Hornoch, D. Mages, P. A. Taylor, A. D. Seymour, C. Snodgrass, U. G. Jørgensen, M. Dominik, B. Skiff, T. Polakis, M. M. Knight, T. L. Farnham, J. D. Giorgini, B. Rush, J. Bellerose, P. Salas, W. P. Armentrout, G. Watts, M. W. Busch, J. Chatelain, E. Gomez, S. Greenstreet, L. Phillips, M. Bonavita, M. J. Burgdorf, E. Khalouei, P. Longa-Peña, M. Rabus, S. Sajadian, N. L. Chabot, A. F. Cheng, W. H. Ryan, E. V. Ryan, C. E. Holt, H. F. Agrusa, Orbital period change of Dimorphos due to the DART kinetic impact, 616 (2023) 448–451.

[2] N. Trógolo, A. Campo Bagatin, F. Moreno, P. G. Benavidez, Lifted particles from the fast spinning primary of the Near-Earth Asteroid (65803) Didymos, 397 (2023) 115521.

[3] S. Naidu, S. Chesley, N. Moskovitz, C. Thomas, A. Meyer, P. Pravec, P. Scheirich, D. Farnocchia, D. Scheeres, M. Brozovic, L. Benner, A. Rivkin, N. Chabot, Orbital and physical characterization of asteroid Dimorphos following the DART impact, in: AAS/Division for Planetary Sciences Meeting Abstracts, volume 56 of *AAS/Division for Planetary Sciences Meeting Abstracts*, p. 312.04.

[4] R. T. Daly, C. M. Ernst, O. S. Barnouin, R. W. Gaskell, H. Nair, H. Agrusa, N. L. Chabot, A. F. Cheng, E. Dotto, E. Mazzotta Epifani, R. C. Espiritu, T. L. Farnham, E. E. Palmer, P. Pravec, A. S. Rivkin, D. C. Waller, A. Zinzi, DART Team, LICIACube Team, An Updated Shape Model of Dimorphos from DART Data, 5 (2024) 24.

[5] O. Barnouin, R.-L. Ballouz, S. Marchi, J.-B. Vincent, H. Agrusa, Y. Zhang, C. M. Ernst, M. Pajola, F. Tusberti, A. Lucchetti, R. T. Daly, E. Palmer, K. J. Walsh, P. Michel, J. M. Sunshine, J. L. Rizos, T. L. Farnham, D. C. Richardson, L. M. Parro, N. Murdoch, C. Q. Robin, M. Hirabayashi, T. Kahout, E. Asphaug, S. D. Raducan, M. Jutzi, F. Ferrari, P. H. A. Hasselmann, A. CampoBagatin, N. L. Chabot, J.-Y. Li, A. F. Cheng, M. C. Nolan, A. M. Stickle, O. Karatekin, E. Dotto, V. Della Corte, E. Mazzotta Epifani, A. Rossi, I. Gai, J. D. P. Deshapriya, I. Bertini, A. Zinzi, J. M. Trigo-Rodriguez, J. Beccarelli, S. L. Ivanovski, J. R. Brucato, G. Poggiali, G. Zanotti, M. Amoroso, A. Capannolo, G. Cremonese, M. Dall'Ora, S. Ieva, G. Impresario, M. Lavagn, D. Modenini, P. Palumbo, D. Perna, S. Pirrotta, P. Tortora, M. Zannoni, A. S. Rivkin, The geology and evolution of the Near-Earth binary asteroid system (65803) Didymos, Nature Communications 15 (2024) 6202.

[6] J. Bigot, P. Lombardo, N. Murdoch, D. J. Scheeres, D. Vivet, Y. Zhang, J. Sunshine, J. B. Vincent, O. S. Barnouin, C. M. Ernst, R. T. Daly, C. Sunday, P. Michel, A. Campo-Bagatin, A. Lucchetti, M. Pajola, A. S. Rivkin, N. L. Chabot, The bearing capacity of asteroid (65803) Didymos estimated from boulder tracks, Nature Communications 15 (2024) 6204.

[7] P. Michel, M. Küppers, A. C. Bagatin, B. Carry, S. Charnoz, J. de Leon, A. Fitzsimmons, P. Gordo, S. F. Green, A. Hérique, M. Juzi, Ö. Karatekin, T. Kohout, M. Lazzarin, N. Murdoch, T. Okada, E. Palomba, P. Pravec, C. Snodgrass, P. Tortora, K. Tsiganis, S. Ulamec, J.-B. Vincent, K. Wünnemann, Y. Zhang, S. D. Raducan, E. Dotto, N. Chabot, A. F. Cheng, A. Rivkin, O. Barnouin, C. Ernst, A. Stickle, D. C. Richardson, C. Thomas, M. Arakawa, H. Miyamoto, A. Nakamura, S. Sugita, M. Yoshikawa, P. Abell, E. Asphaug, R.-L. Ballouz, W. F. Bottke, D. S. Lauretta, K. J. Walsh, P. Martino, I. Carnelli, The ESA Hera Mission: Detailed Characterization of the DART Impact Outcome and of the Binary Asteroid (65803) Didymos, 3 (2022) 160.

[8] C. Gisellu, E. Palomba, F. Dirri, A. Longobardo, D. Biondi, M. Angrisani, G. Massa, E. Nardi, E. Zampetti, D. Scaccabarozzi, B. Saggin, In-Situ Dust Detection for Didymos-Dimorphos Binary System Environment Characterization, in: 54th Lunar and Planetary Science Conference, volume 2806 of *LPI Contributions*, p. 2732.