LONG-TERM EVOLUTION OF DIMORPHOS'S TAIL OBSERVED BY HUBBLE SPACE TELESCOPE.

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Introduction: The successful impact of the DART (Double Asteroid Redirection Test) spacecraft into Dimorphos [1] excavated an ejecta composed of dust particles from µm to cm in size [2] with embedded boulders up to ~2 m observed [3]. A dust tail formed from the low-speed ejecta dust due to solar radiation pressure (SRP) [2, 4] and stayed observable since the impact. Depending on the particle size, slow ejecta dust could be trapped in orbit around Didymos before they are slowly pushed out of the binary system by SRP and feed into the tail [5]. Long-term monitoring of the tail following the previous ejecta observations immediately after the impact [2] will, therefore, reveal the size and size distribution of large dust particles of a few to tens of cm in size, as well as the dynamic process of dust in the binary system. In addition, the long-term evolution of the tail enables comparison of Dimorphos's tail with those of other active asteroids assumed to be driven by impacts or other impulsive dust emission such as rotational disruption, providing unique context for interpreting the observations of active asteroids [2].

We monitor the evolution of the tail using the Hubble Space Telescope (HST). The imaging observations are performed with the Wide Field Camera 3 UVIS channel through the F350LP filter roughly once every three weeks starting from November 30, 2022, and nominally through early July 2023 when Didymos moves into the sun avoidance zone for HST within a solar elongation of 55º.

Results: The tail showed an overall narrow and mostly straight morphology extending roughly in the opposite directions of the heliocentric orbital velocity of Didymos projected in the sky in all images collected as of the end of March 2023. The orientation and the very slight curvature of the tail were consistent with the synchrone [6] corresponding to the dust released at the time of impact or up to one week or so later. The northern edge of the tail was relatively abrupt, whereas the southern edge appeared to be more diffuse, connecting to a faint, diffuse dust to the south of the tail, corresponding to the synchrones with release times up to a few weeks after impact.

Before the end of December 2022, the brightness profile of the tail remained relatively flat, similar to that of the inner part of the tail a few weeks after the impact [2]. The slope of the brightness profile represented a power law differential particle size distribution with an index close to -3.7 as reported in [2] for particles with sizes between 1 and a few mm.

Starting from January 2023, the profile of the tail started to show a decreasing surface brightness towards Didymos, with the turning point at ~2000 km from Didymos. This behavior might indicate a decrease of the number of particles relative to the power law size distribution with a slope of -3.7. The turning point slowly moved away from Didymos and was at ~4000 km from Didymos on March 23, 2023. Preliminary modeling considering the dynamical interactions between the dust and the binary system as well as SRP suggested that the observed tail brightness profile is consistent with the largest particles of ~5 cm in radius.

The overall surface brightness of the tail decreased with time from 85×10^{-8} [W m^{-2} µm^{-1} sr^{-1}] on November 30, 2022, to 4.9×10^{-8} [W m^{-2} µm^{-1} sr^{-1}] on March 23, 2023, roughly following an exponential decrease after corrected for heliocentric distance change. The *e*-fold fading timescale is about 52 days.

Conclusion: The evolution of Dimorphos's tail produced by the DART impact suggests that the largest particles that make significant contributions to the observed tail are probably around 5 cm in radius. Centimeter-sized dust particles continuously feed into the tail after being temporarily trapped in the Didymos binary system for weeks.

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