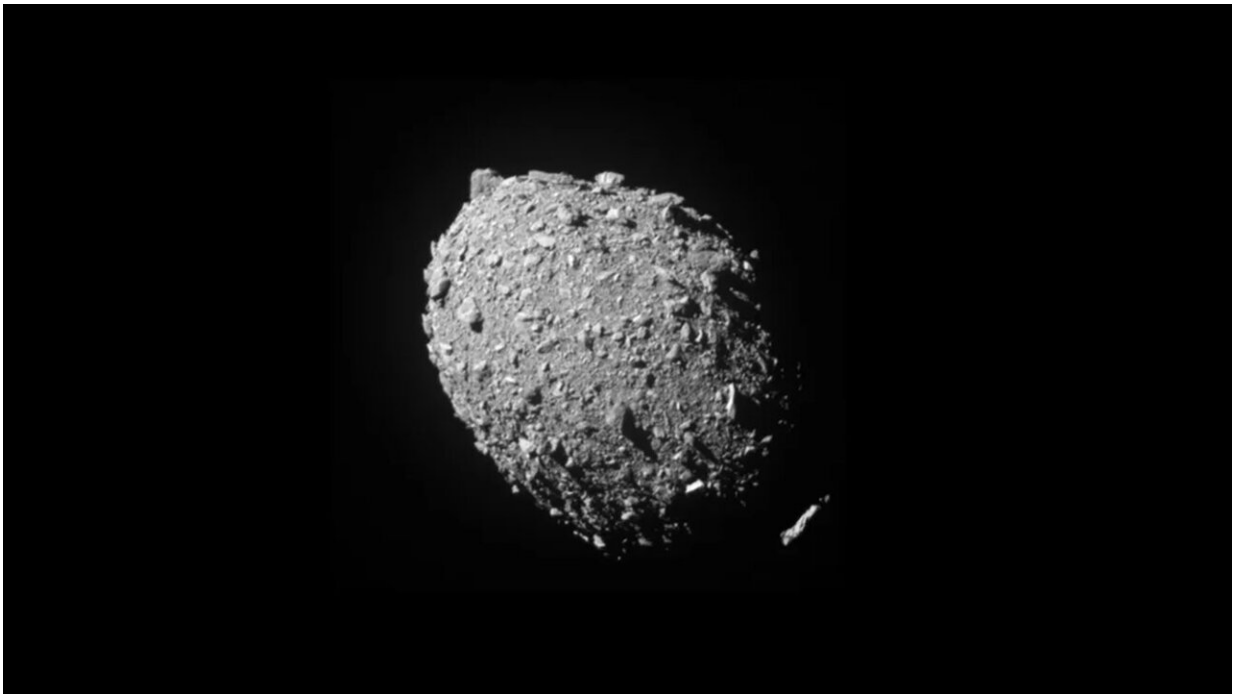


NASA study: Asteroid's orbit, shape changed after DART impact

March 19 2024, by Ian J. O'Neill, Karen Fox, Charles Blue



The asteroid Dimorphos was captured by NASA's DART mission just two seconds before the spacecraft struck its surface on Sept. 26, 2022. Observations of the asteroid before and after impact suggest it is a loosely packed "rubble pile" object. Credit: NASA/Johns Hopkins APL

After NASA's historic Double Asteroid Redirection Test, a JPL-led study has shown that the shape of asteroid Dimorphos has changed and its orbit has shrunk.

When NASA's DART (Double Asteroid Redirection Test) deliberately smashed into a 560-foot-wide (170-meter-wide) asteroid on Sept. 26, 2022, it made its mark in more ways than one. The demonstration showed that a kinetic impactor could deflect a hazardous asteroid should one ever be on a collision course with Earth.

Now, a new study published in the [*Planetary Science Journal*](#) shows the impact changed not only the motion of the asteroid but also its shape.

DART's target, the asteroid Dimorphos, orbits a larger near-Earth asteroid called Didymos. Before the impact, Dimorphos had a roughly symmetrical "oblate spheroid" shape—like a squashed ball that is wider than it is tall. With a well-defined, circular orbit at a distance of about 3,900 feet (1,189 meters) from Didymos, Dimorphos took 11 hours and 55 minutes to complete one loop around Didymos.

"When DART made an impact, things got very interesting," said Shantanu Naidu, a navigation engineer at NASA's Jet Propulsion Laboratory in Southern California, who led the study.

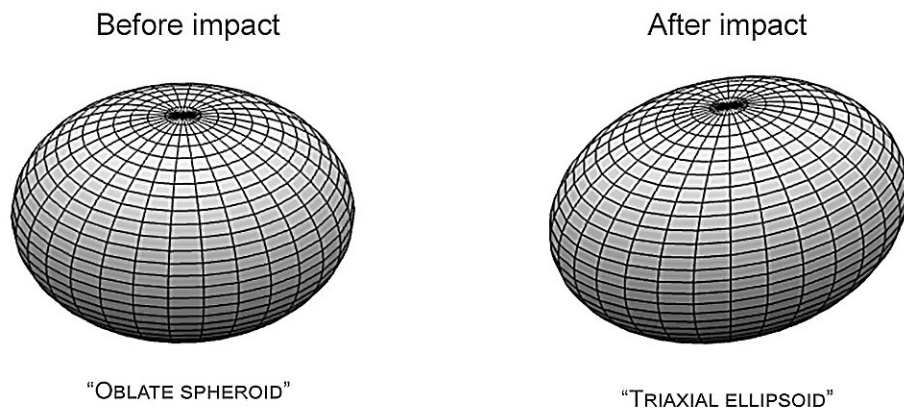
"Dimorphos' orbit is no longer circular: Its [orbital period](#)"—the time it takes to complete a single orbit—"is now 33 minutes and 15 seconds shorter. And the entire shape of the asteroid has changed, from a relatively symmetrical object to a 'triaxial ellipsoid'—something more like an oblong watermelon."

Dimorphos damage report

Naidu's team used three [data sources](#) in their computer models to deduce what had happened to the asteroid after impact. The first source was aboard DART: The spacecraft [captured images](#) as it approached the asteroid and sent them back to Earth via NASA's Deep Space Network (DSN). These images provided close-up measurements of the gap

between Didymos and Dimorphos while also gauging the dimensions of both asteroids just prior to impact.

The second data source was the DSN's Goldstone Solar System Radar, located near Barstow, California, which bounced radio waves off both asteroids to precisely measure the position and velocity of Dimorphos relative to Didymos after impact. Radar observations quickly helped NASA conclude that DART's effect on the asteroid greatly exceeded the minimum expectations.



This illustration shows the approximate shape change that the asteroid Dimorphos experienced after DART hit it. Before impact, left, the asteroid was shaped like a squashed ball; after impact it took on a more elongated shape, like a watermelon. Credit: NASA/JPL-Caltech

The third and most significant source of data is ground telescopes around the world that measured both asteroids' "light curve," or how the sunlight reflecting off the asteroids' surfaces changed over time. By comparing the light curves before and after impact, the researchers

could learn how DART altered Dimorphos' motion.

As Dimorphos orbits, it periodically passes in front of and then behind Didymos. In these so-called "mutual events," one asteroid can cast a shadow on the other or block our view from Earth. In either case, a temporary dimming—a dip in the light curve—will be recorded by telescopes.

"We used the timing of this precise series of light-curve dips to deduce the shape of the orbit, and because our models were so sensitive, we could also figure out the shape of the asteroid," said Steve Chesley, a senior research scientist at JPL and study co-author. The team found Dimorphos' orbit is now slightly elongated or eccentric.

"Before impact," Chesley continued, "the times of the events occurred regularly, showing a circular orbit. After impact, there were very slight timing differences, showing something was askew. We never expected to get this kind of accuracy."

The models are so precise that they even show that Dimorphos rocks back and forth as it orbits Didymos, Naidu said.

Orbital evolution

The team's models also calculated how Dimorphos' orbital period evolved. Immediately after impact, DART reduced the average distance between the two asteroids, shortening Dimorphos' orbital period by 32 minutes and 42 seconds to 11 hours, 22 minutes, and 37 seconds.

Over the following weeks, the asteroid's orbital period continued to shorten as Dimorphos lost more rocky material to space, finally settling at 11 hours, 22 minutes, and 3 seconds per orbit—33 minutes and 15 seconds less time than before impact. This calculation is accurate to

within 1 ½ seconds, Naidu said. Dimorphos now has a mean orbital distance from Didymos of about 3,780 feet (1,152 meters)—about 120 feet (37 meters) closer than before impact.

"The results of this study agree with others that are being published," said Tom Statler, lead scientist for solar system small bodies at NASA Headquarters in Washington. "Seeing separate groups analyze the data and independently come to the same conclusions is a hallmark of a solid scientific result. DART is not only showing us the pathway to an asteroid-deflection technology; it's revealing a new fundamental understanding of what asteroids are and how they behave."

These results and observations of the debris left after impact indicate that Dimorphos is a loosely packed "rubble pile" object, similar to asteroid Bennu. ESA's (European Space Agency) Hera mission, planned to launch in October 2024, will travel to the asteroid pair to carry out a detailed survey and confirm how DART reshaped Dimorphos.

More information: Shantanu P. Naidu et al, Orbital and Physical Characterization of Asteroid Dimorphos Following the DART Impact, *The Planetary Science Journal* (2024). [DOI: 10.3847/PSJ/ad26e7](https://doi.org/10.3847/PSJ/ad26e7)

Provided by NASA

Citation: NASA study: Asteroid's orbit, shape changed after DART impact (2024, March 19) retrieved 27 April 2024 from <https://phys.org/news/2024-03-nasa-asteroid-orbit-dart-impact.html>

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