P52A-06 - First Assessment of the Dynamical State of the Didymos Binary Asteroid System Before and After the DART Impact

Abstract

As a demonstration of kinetic impact deflection, NASA's Double Asteroid Redirection Test (DART) spacecraft nominally impacted the natural satellite of (65803) Didymos, Dimorphos, on 2022 September 26, causing a reduction in the moon's orbital period measurable with ground-based observations. Richardson et al. (2022) gave predictions for the dynamical state of the system both before and after the DART impact. The assumed dynamically relaxed state of the system was predicted to be excited by the impact, leading to an increase in eccentricity and a slight tilt of the orbit, together with enhanced libration of Dimorphos, with the amplitude of the libration dependent in part on the target shape. Free rotation around the moon's long axis could also be triggered and the orbital period could experience variations from seconds to minutes over timescales of days to months. The heliocentric orbit change could also be measurable. Shape change of either body, due to cratering or mass wasting triggered by crater formation (on Dimorphos) and ejecta accretion (on Didymos, which is close to its spin-stability limit), could affect the momentum transfer enhancement factor ("beta") but could be constrained through additional measurements. The shape change of Dimorphos could be dramatic if it is a weak, unconsolidated body. Both BYORP and gravity tides could cause measurable orbital changes on the timescale of ESA's Hera follow-up rendezvous mission. Here we provide our first assessment of these predictions and a first estimate of beta and its uncertainty based on the system dynamics.
Reference: Richardson et al. 2022, PSJ 3:157 (23pp).

Full Abstract

NASA's Double Asteroid Redirection Test (DART) involves deliberately impacting a spacecraft into an asteroid to change its orbit as a hazard mitigation technology demonstration. The DART target is Dimorphos, the small moon of asteroid (65803) Didymos. (Neither Didymos nor Dimorphos are a threat to Earth, and the test does not change this.) The impact shortens the orbital period measurably by an amount that depends on how much momentum is carried away by the generated ejecta. Also, because Didymos and Dimorphos have irregular shapes and are close together, their mutual orbit and individual spins fluctuate a bit. The DART impact excites even larger fluctuations that may be measurable and may give further insight into the physical nature of the asteroids. We present an initial assessment of how well the outcome matched our expectations and what we have learned from the test.

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