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EXPLORING EFFECTS OF SPACECRAFT GEOMETRY AND TARGET STRUCTURE ON THE DART IMPACT

Angela M. Stickle[1,*], Emma S.G. Rainey[1], and Thomas W. Rosch[1]
[1]*The Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723, USA, (240)228-3822*
(*)angela.stickle@jhuapl.edu

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ABSTRACT

The Double Asteroid Redirection Test (DART) mission is the first direct test of the kinetic impactor technique for asteroid impact mitigation. The DART spacecraft will impact the secondary of the 65803 Didymos system in October 2022 and change the orbit period of the moonlet by several minutes. This deflection can be measured from Earth by observing the light curve, and then translated into a momentum transfer efficiency, β. Here, we will discuss modeling of the effects of the DART spacecraft geometry and asteroid properties on the resultant kinetic deflection expected from the DART impact.

The momentum transfer efficiency, β, can vary based on impact conditions, including spacecraft geometry, target properties, and impact location. Simulations examining the magnitude of these effects are ongoing in preparation for the DART mission. Though the DART spacecraft geometry is fixed, future missions may use different spacecraft designs and have different density profiles within the craft, and the

density and size of the spacecraft will have an effect on the crater that is formed. Simulations using models of the DART spacecraft will be compared to more simplified spacecraft models to determine how detailed a spacecraft model is necessary to predict the outcome of the DART impact. This will be useful in future extrapolations of the DART mission results.

The effects of target near-surface and interior structure are also of interest. As a larger number of asteroids are visited by spacecraft, evidence is increasing that many structures are likely to be rubble piles. Images of both Ryugu and Bennu, by the Hayabusa 2 and OSIRIS-REx spacecraft, respectively, show small worlds covered in boulders of various sizes. This characteristic likely extends to smaller bodies, such as the moon of the Didymos system. Preliminary two-dimensional models of impacts into rubble pile targets suggest that the distribution of boulders within the matrix material can have significant effects on the impact process and the deflection expected, changing β by a factor of ~2. Simply adding macroporosity, in the form of boulders within a matrix, compared to microporosity has significant ramifications for the simulated β and velocity change of the target asteroid. Initial simulations suggest that a rubbly target will experience a significantly higher velocity change compared to a more competent target for the same impactor energy. Further, simulations suggest that where the impact occurs with reference to boulders (on a boulder v. near or far from one) can affect the cratering process, ejecta evolution, and momentum transfer. Even impacts into matrix material can disrupt nearby boulders, increasing the momentum enhancement.

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