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MODELING THE DART IMPACT: EFFECTS OF SURFACE MORPHOLOGY AND RUBBLE PILE STRUCTURE ON DEFLECTION OBSERVABLES

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ABSTRACT

NASA's Double Asteroid Redirection Test (DART) mission is the first space demonstration of the kinetic impactor technique for asteroid deflection. DART's target for deflection was Dimorphos, the moonlet of the Didymos binary asteroid system. At 23:14 UTC on Sept 26, 2022, the DART spacecraft impacted Dimorphos at 6.14 km/s, resulting in a reduction in the binary orbital period of 33.0 +/-1.0 (3 σ) minutes. Images taken by DART's navigation and targeting instrument, the Didymos Reconnaissance Asteroid Camera for Optical navigation (DRACO), during approach showed that Dimorphos is an oblate spheroid with a rocky, boulder-covered surface. Initial estimates of the boulder size distribution on the surface of Dimorphos give a mean boulder diameter of ~1.2 m (assuming a minimum cutoff size of 0.6 m) and a maximum diameter of ~6.0 m, comparable to the size of the main DART spacecraft structure, which was ~1.5 m with two ~8.5 m solar arrays.

The DART Impact Working Group, which is part of the DART Investigation Team, is tasked with modeling the DART impact outcome and interpreting the impact results. To build a detailed understanding of the momentum transfer, cratering process, and ejecta dynamics that occurred during the DART impact, it is important that models of the DART impact account for the effect of boulders on and near the surface, as well as the possibility that Dimorphos has a “rubble pile” structure throughout its interior. We present results from 2D and 3D numerical simulations investigating the effects of Dimorphos surface morphology and potential subsurface structures on DART impact observables, which include deflection magnitude, deflection efficiency, and crater morphology. The simulations were run using the CTH shock physics code, and observations of Dimorphos and the DART impact were used to constrain input parameters where possible. Initial 2D axisymmetric modeling results showed that surface and near-surface morphology have significant effects on the momentum transfer efficiency, ejecta mass-velocity distribution, and transient crater dimensions, while the influence of deeper subsurface structure is minimal. These models have recently been extended to 3D, and in this presentation the 3D simulation results will be described and compared with the 2D axisymmetric simulations.

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