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Ongoing and Upcoming Mission Highlights

Impact Simulations Provide Critical Information to Constrain Dimorphos's Material Properties and Better Understand the DART Impact

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ABSTRACT

On September 26, 2022, the Double Asteroid Redirection Test (DART) spacecraft intentionally collided with Dimorphos, the moon of the binary asteroid system 65803 Didymos. This collision provided the first full-scale test of a kinetic impactor for planetary defense. Images from DART's DRACO camera revealed Dimorphos to be a rubble-covered oblate spheroid. The DART collision changed the orbital period of Dimorphos around Didymos by 33 minutes, which translates to an orbital velocity change of ~2.7 mm/s and a momentum enhancement factor, β, of ~3.6 assuming the density of Dimorphos is 2400 kg/m^3. The follow-on images from the ASI-led cubesat LICIAcube revealed spectacular ejecta clouds immediately following impact, with a complicated ejecta structure and potential ejected boulders.

Very little was known about Dimorphos prior to DART's impact, including its shape, structure, and material properties. As such, a large parameter space was modeled by the DART Impact Modeling Working Group (IWG) in advance of the impact. Compiling nearly 10 years of simulations provided predictions that β would be between 1-5, depending on material properties (Stickle et al. 2022). These simulations covered a wide range of potential material properties, including strength, porosity, friction coefficient, etc. Observations following the DART impact have provided some additional crucial constraints that will narrow the parameter space to be narrowed. Early simulations suggest that multiple combinations of material properties (e.g., strength and porosity) and target structure (e.g., rubble pile, boulder arrangement and packing, subsurface structure) can match critical DART observations. No single simulation has yet, or is likely to, explain every key observation from DART because many properties remain unconstrained (subsurface structure, etc) or highly uncertain (e.g., density and mass of Dimorphos). Following from the predictions of the DART IWG, we will discuss how the observations following the DART impact (e.g., period change, ejecta, surface morphology) combined with the insights gained from impact simulations can help reduce the uncertainty in Dimorphos's material properties. Synthesizing results from a variety of simulations provides one of the best ways to evaluate potential "best-fit" properties of Dimorphos. The constraints from the simulations will also provide additional information regarding how data from Hera can further constrain Dimorphos's material properties after it arrives at the Didymos system.

References: Stickle, A. M., DeCoster, M. E., Burger, C., Caldwell, W. K., Graninger, D., Kumamoto, K. M., ... & Wünnemann, K. (2022). Effects of impact and target parameters on the results of a kinetic impactor: predictions for the Double Asteroid Redirection Test (DART) mission. *The Planetary Science Journal*, *3*(11), 248.

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