PRELIMINARY RESULTS FROM MODELING THE KINETIC IMPACT OF THE DART SPACECRAFT INTO DIMORPHOS.

W. K. Caldwell[1] and C. S. Plesko[1], [1]Applied Computational Physics Division, Los Alamos National Laboratory, wkcaldwell@lanl.gov.

Introduction: The National Aeronautics and Space Administration (NASA) Double Asteroid Redirection Test (DART) spacecraft successfully impacted Dimorphos on September 26, 2022. The mission was the first of its kind to test the kinetic impactor deflection method for planetary defense. Prior to launch, several case studies were performed across a number of hydrocodes that would be used in further mission simulations [1]. Prior to impact, the Investigation Team ran a number of simulations of plausible impact scenarios, including two inverse tests that simulated the type of data that would be available to modelers after impact [2,3].

Since the spacecraft impacted Dimorphos, the modeling efforts have shifted to included updated shape models of Dimorphos, surface features of Dimorphos determined by mission images, spacecraft mass and velocity, and the momentum enhancement and resulting period change. Here, we share preliminary 2D and 3D hydrocode models of the DART impact using a number of material compositions and configurations of Dimorphos using the hydrocode FLAG, which has been used to successfully model high-velocity impacts, including pre-impact simulations of the DART mission [2,3,4,5].

Methods: The FLAG hydrocode, developed and maintained by Los Alamos National Laboratory, is an arbitrary Lagrangian-Eulerian (ALE) code that models both solids and fluids [6,7]. FLAG can model high-velocity impacts in 1–3 spatial dimensions and includes such features as adaptive mesh refinement (AMR), tabular and analytic equations of state (EOS), and strength and damage models to capture solid mechanical properties [6,7,8].

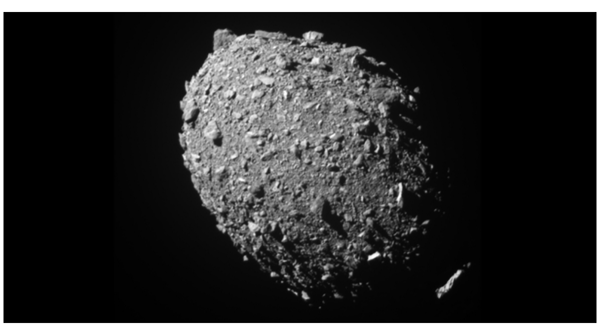

Figure 1: Image of Dimorphos, the target asteroid in NASA's DART mission, prior to spacecraft impact. Image credit: NASA/Johns Hopkins Applied Physics Laboratory.

Results: In 2D axisymmetric geometry, we explore preliminary estimates of the material composition of Dimorphos that could lead to the observed momentum enhancement and period change from the DART mission. Our 2D models include porosity.In 3D, we consider more complex compositions of Dimorphos, including rubble-pile configurations, which are difficult to model in 2D because of the introduction of artificial hoop stresses in axisymmetric simulations. Although 3D simulations are much more computationally expensive than their 2D counterparts, they allow for a more thorough numerical investigation of rubble-pile structures, spacecraft geometry, and oblique impact angles.

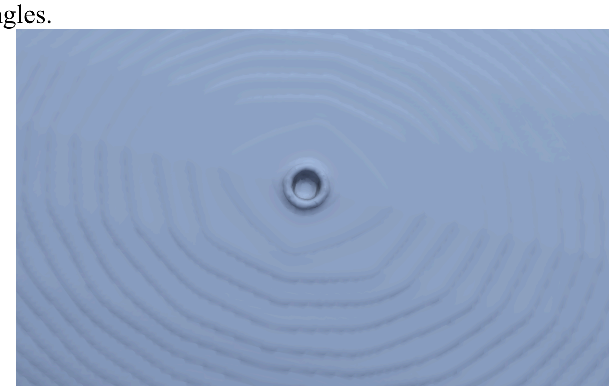

Figure 2: Crater from a FLAG simulation of the first DART inverse test, performed prior to impact.

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