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Deflection & Disruption Modeling and Testing

Hydrodynamic Simulation of the Explosively Formed Projectile for Crater Formation on the Asteroid Ryugu from Hayabusa2

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In 2018, the Japanese Aerospace Exploration Agency's (JAXA) Hayabusa2 spacecraft launched an EFP at the asteroid 162173 Ryugu. The copper slug used by JAXA was 2 kilograms in mass and impacted the surface at 2 km/s at 30 degrees off normal. The collision resulted in a semi-circular crater with a 14-meter diameter. In this paper, we simulate the explosively formed projectile (EFP) used to create the artificial crater on the asteroid Ryugu and compare the projectile's shape to ground based images. Accurate modeling of this impact event can provide insight into Ryugu's material properties and serve as validation event for future impact simulations. This paper details the EFP simulations, compares the projectile formation to ground-based experiments, proposes simple EFP shape approximations and gives a framework for the 3-D impact modeling. Using the Lagrangian-Eulerian hydrocode ALE3D, we model the full formation and propagation of the copper slug through air in 2-D and compare the shape to ground-based high-speed images taken by JAXA. The minimum resolution needed to maintain accurate physical behavior of the EFP is also determined. Next, in 2-D we explore 2 kg hollow spherical and hemispherical representations for the EFP that produce impact craters of the same size and depth as a fully formed projectile at normal incidence. Of the shapes explored, we determine a hollow hemisphere with radius 9.49 cm, shell thickness 0.35 cm, and mass 2 kg provides the best impact approximation. Finally, we explore in 3-D the impact of this simplified projectile at an impact angle 30 degrees off normal into the surface of Ryugu using Spheral, an Adaptive Smooth Particle hydrocode. 3-D simulations are necessary, due to the non-vertical impact angle and impact-site structural heterogeneities, which appear to have played a key role in formation of the semi-circular crater shape. We explore the effects of impact angle, surface boulders, and different subsurface layers on crater morphology, with an emphasis on lessons learned ahead of the 2022 DART impact experiment at asteroid Dimorphos.

Comments:
I'd like to give an oral presentation, and if that isn't possible then I would do a poster session presentation.

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