PDC2023
Vienna, Austria

TOPIC: Deflection / Disruption Modeling & Testing

HYPERVELOCITY BOLIDE DISRUPTION SIMULATIONS FOR PLANETARY DEFENSE

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Keywords: *Planetary defense, Hypervelocity impacts, Asteroid fragmentation, Near Earth objects*

ABSTRACT

We present a hypervelocity impact simulation campaign aimed at exploring the efficiency of total disruption via kinetic impactors as proposed by the PI ("Pulverize It") method of Lubin et. al. The simulations explore a variety of mission scenarios involving different types, configurations, arrays, and successive waves of 10:1 aspect ratio 100 kg cylindrical tungsten penetrators, along with variations in the material properties and sizes of the target bolide. We systematically introduce models for yield strength, porosity, and heterogeneity (yield strength and boulder distributions) so as to better understand the effect of each on the efficiency of disruption and the generation of a fragment cloud. This simulation campaign makes use of the LLNL arbitrary Lagrangian–Eulerian (ALE) hydrodynamics code ALE3D using the High-End Computing Capability (HECC) at NASA Ames Research Center. With ALE3D, we are able to model hypervelocity impact dynamics using extreme equation-of-state material models in 2D and 3D, which ultimately informs the design of more efficient penetrators. Our simulation campaign is currently underway and funded by a NASA NIAC Phase I study, which also includes running CTH simulations at LANL. We show that terminal interdiction modes ranging from 2 minutes prior to impact for 20-meter class bolides (such as the Chelyabinsk asteroid), 1 day prior to impact for 100 m-class asteroids, 10 days prior to impact for Apophis-class asteroids (~ 370 m), and even 60 days prior to impact for 1 km-class threats are all possible, though longer warning times are always preferred. Compared to other threat reduction methods, this approach represents an extremely logical, cost-effective, testable, and deployable approach with a practical roadmap to development. This approach also requires much less launch mass for a given threat when compared to deflection techniques. The effectiveness of the approach depends on the time to intercept and the size and composition of the bolide, but allows for effective defense against asteroids in the multi-hundred-meter diameter class and could virtually eliminate their threat within extremely short response times. Using only technologies readily available today, the PI method allows for a cost-effective and practical roadmap towards robust planetary defense capability.

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Comments: *N/A*