IAF SYMPOSIUM ON PLANETARY DEFENSE AND NEAR-EARTH OBJECTS (E10)
Planetary Defense from Asteroids and Comets (1)

Author: Ms. Minh Lê
The Johns Hopkins University, United States, mle20@jh.edu

Mr. Justin Moreno
The Johns Hopkins University, United States, jmoreno8@jhu.edu
Prof. K.T. Ramesh
The Johns Hopkins University, United States, ramesh@jhu.edu

HYPERVELOCITY IMPACT STUDIES ON RUBBLE PILE ASTEROIDS

Abstract

The first planetary defense mission, DART, proved that it is possible to change the orbital path of an asteroid via kinetic impact. The effectiveness of the kinetic impact method is quantified in terms of the momentum enhancement factor β, which is known to depend on the structure and properties of the target body at the time of impact. The penultimate image from the DART spacecraft showed the surface of the rubble pile asteroid Dimorphos is covered with large boulders. It is likely that the "strength" of an individual boulder will be greater than the strength of the collective rubble pile, and thus an impact into the boulder rather than the underlying granular bed could result in very different effectiveness of the kinetic impactor.

This work seeks to investigate the effects of the strength of the impacted boulder on the momentum enhancement factor, and implications for mission design, by performing hypervelocity impact experiments on a basalt sample sitting on a sand bed to simulate a rubble pile target. 3 mm spherical aluminum impactors were launched at 3-5 km/s in a horizontal two-stage light gas gun to study the ejecta and crater development within the target. Data analysis includes in-situ diagnostics with flash X-ray to study penetration during impact and high-speed camera imaging at 10,000 – 2 million frames per second (microseconds to milliseconds timescale) to capture the short- and long-term evolution of the ejecta cloud and cracks propagation within the basalt.

The boulder played a significant role in crater formation by absorbing most of the kinetic energy transferred from the impactor. When the target was impacted at 3 km/s, a crater did not form on the sand bed while the basalt was disrupted. Meanwhile, a higher impact velocity of 5 km/s left a crater in the sand. The characteristics of the boulder change the outcome of the impact. The results of this study aid with the understanding of the resulting momentum enhancement factor from a highly heterogeneous system and can be applicable to future planetary defense mission designs.