METEORITE MATERIAL PROPERTIES FOR USE IN IMPULSIVE ASTEROID DEFLECTION SIMULATIONS

M. Bruck Syal[1], L. Chen[2], E. B. Herbold[1], J. M. Owen[1], D. Swift[1], P. L. Miller[1] [1]Lawrence Livermore National Laboratory (LLNL) [2]Imperial College London. E-mail: syal1@llnl.gov.

Introduction: Hazardous asteroids can be diverted from Earth-impacting trajectories using high-speed kinetic impactors or surface ablation by stand-off nuclear devices; asteroid size and impact warning time strongly influence the effectiveness of each approach [1]. Accurate modeling of asteroid response to these impulsive deflection strategies requires both knowledge of an asteroid's material properties (e.g., composition, porosity, strength, internal structure) and incorporation of the relevant energy-dissipation mechanisms (e.g., vaporization, melting, void crushing, comminution, fracture) into the numerical methods used to simulate the event. Here we describe high-strain-rate experiments on chondritic material to address the first source of uncertainty, along with advancements in numerical modeling techniques to address the second source of uncertainty. Continued refinements in planetary defense will be enabled by additional geotechnical data on the diverse types of meteorites available for study.

Chondrite Experiments: Pieces of the Allende (CV3), Holbrook (L/LL6), Allegan (H5), and Tamdakht (H5) meteorites have been acquired for high-strain-rate (10^5 – 10^7 s^{-1}) strength experiments at the Janus laser facility at LLNL. Microstructure, composition, and density of the samples will be characterized in detail before and after the experiments. In order to probe the effects of regolith porosity (likely important at many asteroids), both solid and granular samples will be used. Experiments will measure pressure dependence of yield strength, dynamic tensile strength, and capture phase-change information. Temperature effects on strength (100 K - 1000 K) also will be investigated, using a custom-built system to cool and heat chondrite samples.

Numerical Results for Asteroid Deflection: Recent work highlights the sensitivity of asteroid response, in both kinetic- and nuclear-deflection scenarios, to asteroid material properties including composition, porosity, and strength [2,3,4]. Development of new constitutive models [2,3] will be enhanced by the availability of new experimental data on chondrites. We will present the most recent results for material-properties effects on asteroid-deflection calculations, using both the GEODYN (Eulerian) [2,3] and Spheral (Adaptive Smoothed Particle Hydrodynamics) [4,5,6] shock-physics codes.

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Part of this work was funded by the Laboratory Directed Research and Development Program at LLNL under project tracking code 12-ERD-005, performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-670796.