PDC2025
Stellenbosch, Cape Town, South Africa

Please submit your abstract at https://iaaspace.org/pdc.

Earth Impact Effects & Consequences

Spheral Simulations of the Atmospheric Entry and Energy Deposition of PDC25 Threat Scenario Asteroids

Evan Bjonnes[1, 2], Jason M. Pearl[1], Kathryn M. Kumamoto[1], J. Michael Owen[1]
[1] Lawrence Livermore National Laboratory, Livermore, CA
[2] bjonnes1@llnl.gov

Keywords: *Consequence Assessment, Airburst, Hydrocode*

The atmospheric breakup of an incoming asteroid and deposition of its energy into both the atmosphere and ground is of great interest to the planetary defense community. The breakup of an incoming asteroid will heat the atmosphere and generate a shockwave and is highly dependent on the asteroid's size, physical characteristics, and incoming trajectory. In this contribution, we analyze how the PDC25 scenario object might fragment in the atmosphere depending on entry angle and asteroid properties. Based on information available at Epoch 1, we examine four different asteroid sizes: 77 m (5th percentile), 127 m (50th percentile), 191 m (95th percentile), and 278 m (100th percentile).

Here we use the SPH code Spheral to perform a parametric study analyzing the amount of energy deposited in the atmosphere by different realizations of the PDC hypothetical threat scenario. We consider three variables: asteroid size, asteroid strength, and incoming angle. Models are run using the open-source smooth particle hydrodynamics code Spheral with the FSISPH solver. Spheral is maintained by Lawrence Livermore National Laboratory, and the formulation used in FSISPH is designed to better model impacts between materials with large discontinuities in properties, such as rock and air. For our parameters, we use the four asteroid diameters described above set forth by the PDC25 scenario. Each tested asteroid is run with an Aba Panu-like strength model and as a fully hydrodynamic object. Aba Panu is relatively strong meteor and is a likely overestimation of asteroid strength and the fully hydrodynamic case, while closer to a rubble pile scenario, is likely an underestimation of asteroid strength. We select three entry angles: a generic 45° case, a near-vertical entry angle associated with an impact point at Cape Town (86.7°), and a shallow case (20°)

Figure 1 summarizes our initial results from our initial 2D analysis. In each case, we find that the fully hydrodynamic bolides break up higher in the atmosphere and have less, if any, intact material that would impact the surface. Similarly, larger bolides remain intact over longer trajectories and are more likely to impact the surface with intact material. Incoming angle also has a notable effect, where a bolide with a shallower incoming angle will tear apart higher in the atmosphere because of the longer travel time needed to reach the surface. Although an incoming angle of 45° is usually assumed for impact studies, these results indicate that the incoming angle has a large influence

over the predicted effects and care is needed to accurately determine the location-specific details of a future impact event. Ongoing work will consider these models in 3D and seek to understand the distribution of energy deposition in the atmosphere and ground under the range of possible PDC25 scenarios. These next steps will help us understand how much asteroid energy is converted to threat effects such as blast waves and ground shock after a putative asteroid encounter.

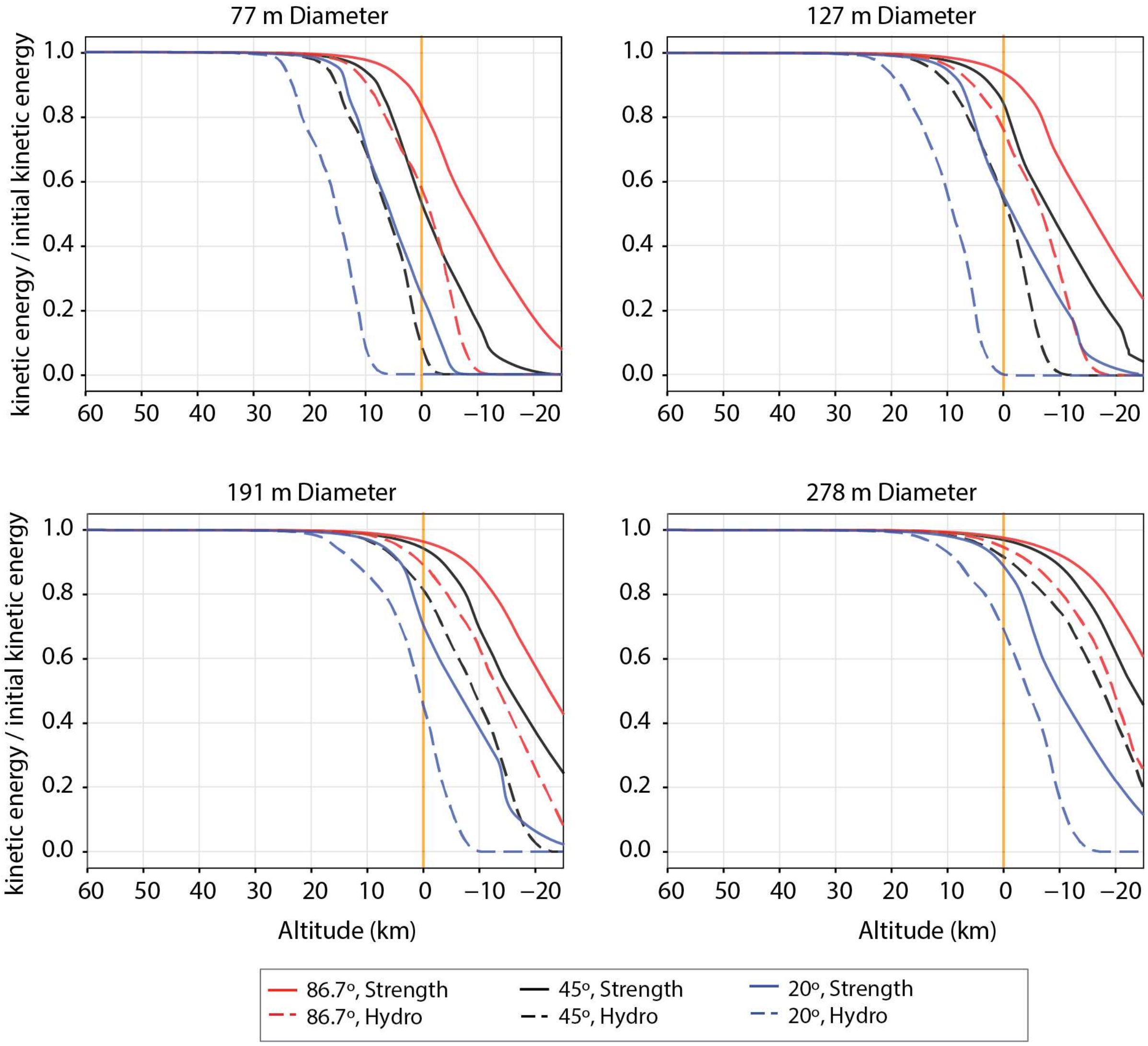

Figure 1: Normalized kinetic energy as a function of altitude, organized by object size. The orange line marks the surface and is intended to guide the eye. Solid lines denote asteroids with strength and dashed lines denote ones with no strength (fully hydrodynamic). Three incoming angles are shown in each plot: 86.7° (red), 45° (black), and 20° (blue).

Comments: Prefer oral session

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-2001174.