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☐ **Hypothetical Asteroid Threat Exercise**
☐ **Deflection / Disruption Modeling & Testing**

Probing heuristics for the kinetic disruption of asteroids

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The potential for accidental disruption of an asteroid during a kinetic impact deflection attempt poses significant risks for planetary defense strategies. As the velocity change applied to an asteroid during a deflection attempt increases, so does the likelihood of inadvertent fragmentation or partial disruption. Understanding the thresholds for safe deflection is crucial, as exceeding these limits can lead to unintended consequences, such as the creation of a cloud of hazardous fragments that may pose a residual threat, one that is potentially equal to or greater than that posed by the original object. Additionally, understanding the requirements for an intentional robust disruption that produces small, well-dispersed fragments opens additional mitigation mission design possibilities.

The characteristics of both the asteroid and the impactor influence the outcome of a kinetic impact. Asteroids exhibit a wide range of sizes, shapes, compositions, and structures, all of which affect an asteroid's response to an impulsive deflection attempt. Properties like porosity and cohesive strength, for instance, have been shown to significantly affect impact cratering as well as the efficacy of a deflection attempt and fragmentation risk. The mass, velocity, shape, and impact angle of the impactor also affect the response of the asteroid and therefore the final outcome of a mitigation mission.

We use impact simulations in the smoothed-particle hydrodynamics code, Spheral++, to examine the effects of systematically varying a subset of these properties. We particularly focus on 3D simulations of the asteroid in the PDC25 hypothetical threat exercise to examine possible risks associated with an attempted kinetic deflection both with and without reconnaissance. An exemplar simulation output is shown in Figure 1. We compare our simulations to several heuristics for asteroid disruption, including the velocity change as a fraction of escape velocity (e.g., [1]), the specific energy of impact (e.g., [2]), and the specific energy of shattering or disruption (e.g., [3]).

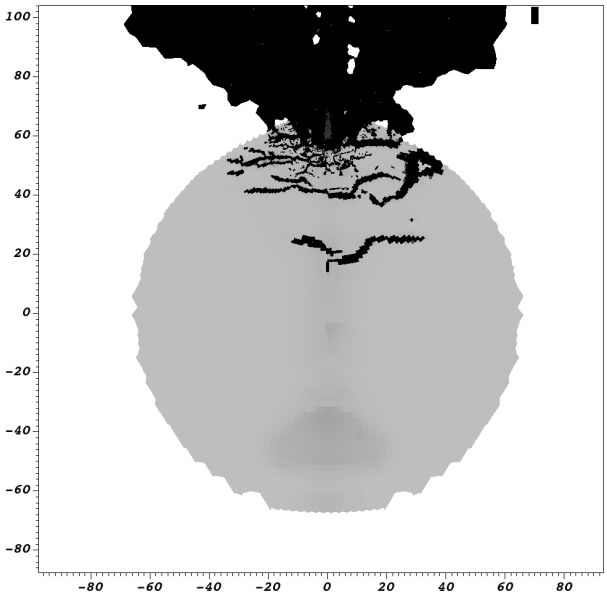

Figure 1: A 2D slice of a 3D simulation of an impact into a monolithic asteroid. This case represents the 50th percentile object, by mass, during Epoch 1 of the PDC25 scenario. The asteroid material is modeled as initially intact rock (light grey), and it fractures and damages (black) beneath the impactor.

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