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○ **Deflection & Disruption Modeling and Testing**

PROGRESS ON DEVELOPING A SIMPLIFIED MODEL OF X-RAY ENERGY DEPOSITION FOR NUCLEAR MITIGATION MISSIONS

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In the event of a potential Near-Earth Object (NEO) impact, with sufficient warning time, a mitigation mission could be launched to divert the object's trajectory or destroy it entirely, depending on the size. Though a kinetic impactor is the preferred technology for a mitigation mission [1], there are instances where it would be insufficient to avert disaster. In such cases, employing a nuclear device is an alternate option. However, despite being the most mass-efficient mission-type, like the kinetic impactor, the effectiveness of a nuclear device is highly dependent on the NEO's physical properties, such as size, shape, mass, composition, and structure, all of which may be poorly constrained before the mission is launched. Thus, having a high-fidelity but efficient way of modeling an NEO's response to the radiation emitted by a nuclear device (mostly x rays) is necessary for exploring the uncertainties and sensitivities that arise from the unknown NEO properties. We present progress on developing a two-part process for simulating a NEO deflection/disruption from x rays emitted by a nuclear device. We use the Kull multiphysics code, which is a fully-coupled radiation hydrodynamics simulation with Implicit Monte Carlo (IMC) transport to simulate the physically complex process of x rays penetrating into the NEO's surface and depositing their energy, which happens quickly after the device is detonated and before the heated material has much chance to move. From these full rad-hydro simulations, we take an angle-dependent time-slice of the energy deposition profile (some examples are shown for a 1D SiO_2 column at various angles and densities in Figure 1) and use it to initialize a hydrodynamics simulation in Spheral, an Adaptive SPH code that is well-suited for modeling shock propagation in asteroidal materials and structures. In turn, Spheral can be used to track the NEO's response to the device's x rays at long timescales and return information on the deflection velocity and any potential fragmentation. A snapshot from a nuclear deflection Spheral simulation of a Bennu-shaped asteroid (scaled to a 300m diameter) can be seen in Figure 2. This method can then be used to explore the vast model space of an NEO's potential properties and to define criteria for the threshold between deflection and disruption. Some preliminary data showing the accuracy of the time-slice energy depositions compared to the full calculations are shown in Figure 3. We will present an update on the latest x-ray ablation modeling methodology advances, along with a deflection sensitivity analysis to asteroid characteristics.

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Comments:

(If possible, an oral presentation would be preferred. Thank you!)

References

[1] N. R. Council, Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies, The National Academies Press, Washington, DC, 2010.

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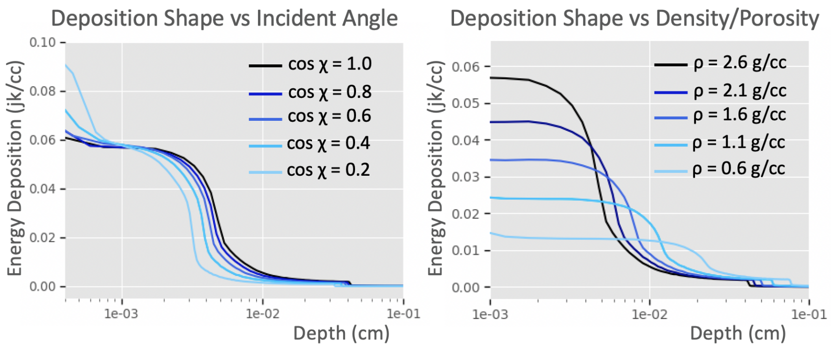

Figure 1: X-ray energy deposition shapes in a 1D column of SiO_2 from an 80 kiloton 1 keV black body source at a 50 m standoff distance with: various angles of incidence (left) and at normal incidence with various densities/porosities (right). For reference, 1 jerk = 1e16 ergs of energy.

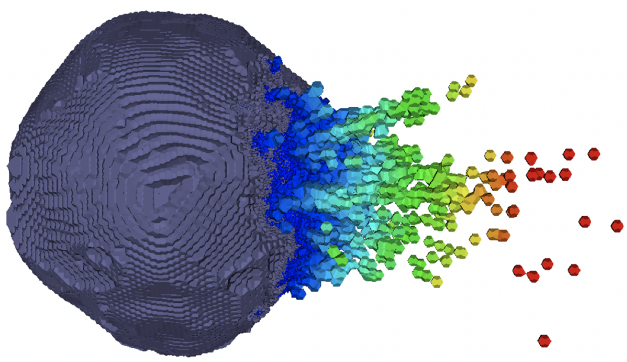

Figure 2: A snapshot taken at 2ms of an example nuclear deflection with a Bennu-shaped asteroid scaled to a 300m diameter in Spheral using an 80 kiloton 1 keV black body source at a 50m standoff distance. Red indicates material moving at 100 km/s or greater.

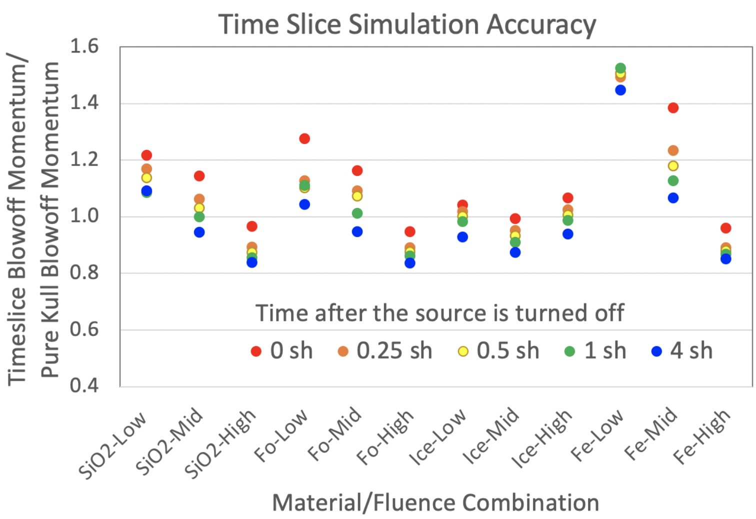

Figure 3: Preliminary data comparing the blowoff momentum from 1D Kull simulations using the full radiation hydrodynamics capabilities with Kull simulations initialized by a time-slice of the energy deposition taken from a full Kull calculation. The colors correspond to the time the spline was taken after the source was turned off. Comparisons were done for four materials: SiO_2, Forsterite, Iron, and Ice at fluence levels that would correspond to an intense disruption (High) to barely melting the asteroid surface (Low).