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ASTEROID DEFENCE: COMPARISON OF KINETIC-IMPACT AND NUCLEAR STAND-OFF SCHEMES

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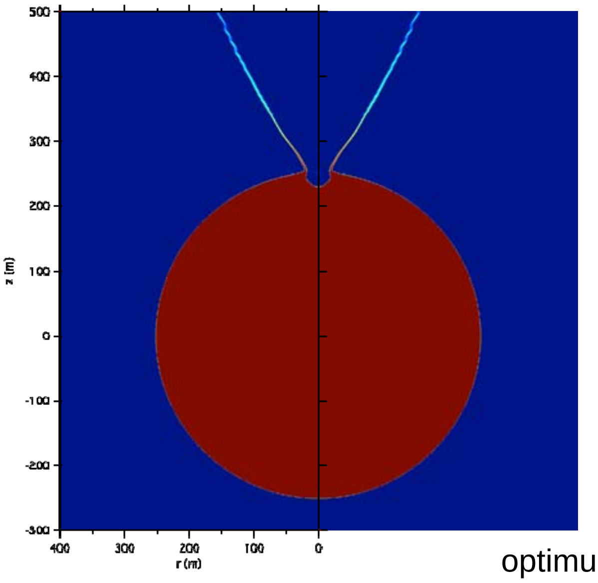
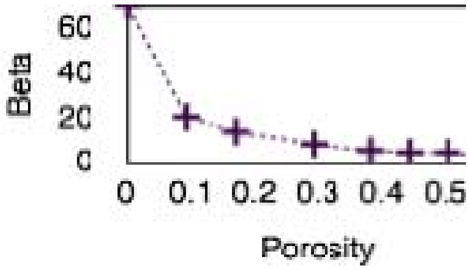
ABSTRACT

The deflection of hazardous near-earth objects can be accomplished using either a kinetic impactor or a nuclear stand-off burst. If the object is known to be competent, the kinetic impactor is shown to be highly efficient. The momentum delivered to the object can be considerably greater than the momentum of the impactor because of the reaction force produced by ablation from the impact crater. We use the adaptive-mesh hydrocode Rage [Gittings et al., Computational Science and Discovery, 1, 015005] to study the momentum-enhancement factor, or beta, varying the assumptions regarding the equation of state and the porosity of the target. For volatile-poor objects, porosity is found to have the strongest effect on beta, since the crushing of pore space attenuates the shock and reduces ablation. Nonporous objects can have beta factors of 50 or more, while the beta factors for porous objects range from 1 to 5. Spall from the back side of the asteroid, which partly counters the favorable effect of ablation, is also included in the calculations, although it is of concern only for nonporous objects.

Figure 1. Left is a density plot at 0.1 second for a kinetic impact calculation, a 1 metric ton iron cannonball onto a 500 meter diameter basalt sphere at 20 km/s. Above is plotted the run of beta with porosity for 8 similar calculations.

For objects not known to be competent, or when the available lead time is short, the nuclear stand-off burst option is preferable. In this case, crucial questions surround the optimum height of burst and the radiation characteristics of the burst. The Rage

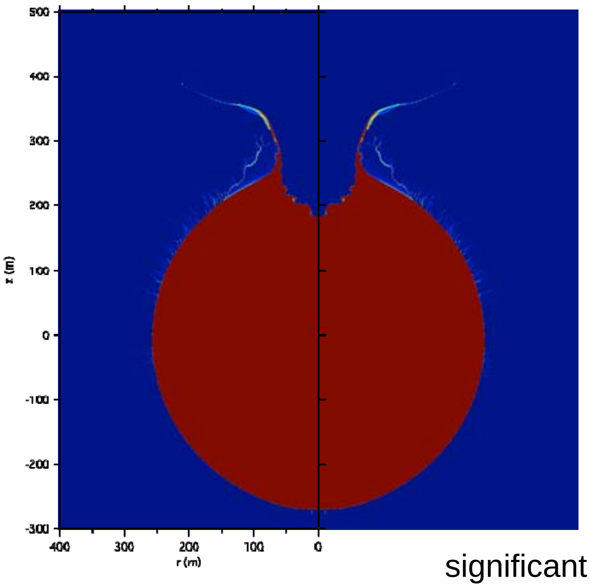


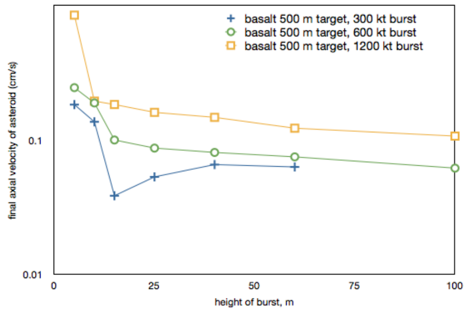


hydrocode, with radiation diffusion included, is also used to study this case. Figures of merit from both these studies include the bulk momentum imparted to the asteroid and the degree to which the asteroid is disrupted. We find the optimum height of burst for a 500 m asteroid to be about 10 m.

Figure 2. Left is a density plot at 14 seconds after a 600 kT burst at 5 m standoff distance from a 500 m diameter basalt sphere. Above is plotted the run of final axial velocity against standoff distance for three different burst yields.

In this study, besides varying porosity for both scenarios and height of burst for the nuclea





option, we have also considered different strength models and equations of state. These have modest effects on the figures of merit. We have not, however, used equations of state for volatile-rich materials, which could make some significant differences. Shape effects and non-axial placements are beyond the scope of the present study, but would of course be highly important in the event of a real threat.

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