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Deflection / Disruption Modeling & Testing

EXTENDING NEO DEFLECTION FORMULAE TO HIGH FLUENCES

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ABSTRACT

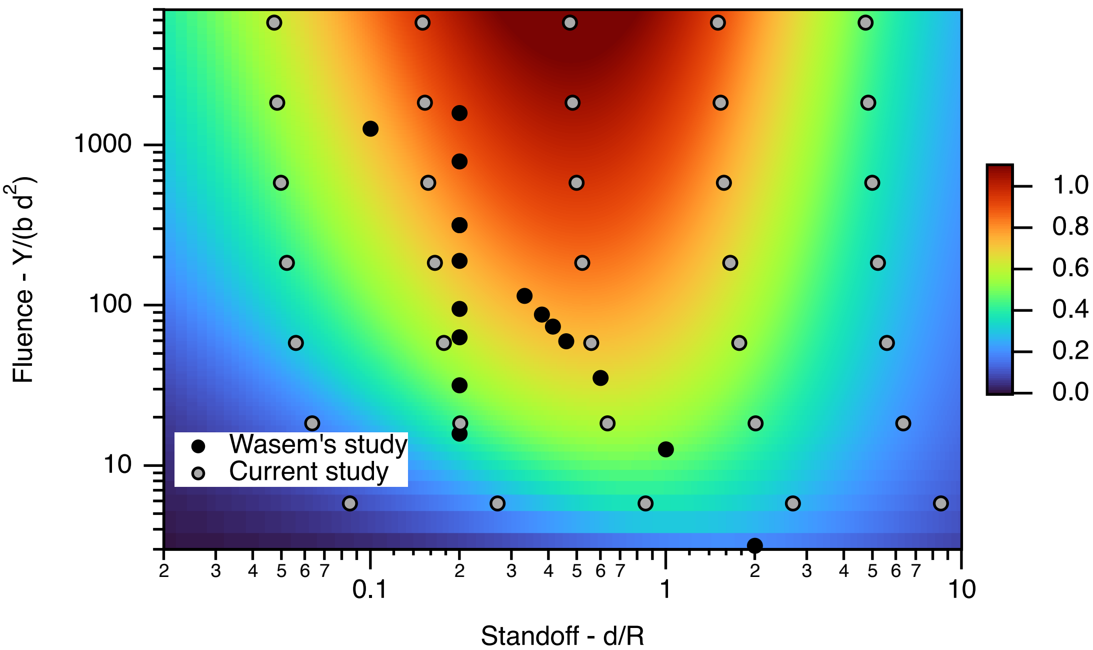
Despite the fact that the DART mission showed the viability of deflecting and asteroid by a kinetic impactor, there are many scenarios where an impactor would not be sufficient to prevent an Earth impact. The best alternative is to use a nuclear explosive, which can deliver significantly more energy to an asteroid for the same payload mass. The explosive will project neutrons, gamma rays, x rays, and hot debris onto the asteroid. The first three will heat the surface of the asteroid to different depths and vaporize the surface layer of the asteroid so that it blows off and imparts momentum to the remainder of the asteroid. Of these, the x rays deliver the most energy. At larger standoff distances and therefore lower fluences a large portion of the asteroid surface is illuminated and it is possible to gently deflect the asteroid. At short standoff distances a smaller portion of the asteroid's surface is illuminated with a higher fluence, thus creating a stronger shock, which can either deflect or disrupt the asteroid depending on the material properties and total energy of the explosive.

A full radiation-hydrodynamic calculation is required to calculate the deflection from a nuclear explosive. They are difficult and time consuming to run. Burkey et al. have run a large number of such calculations on several materials (SiO_2, Forsterite, Fe, and Ice) to construct an energy deposition model that allows you run a hydrodynamics only calculation to determine the blow-off momentum and resulting Δv of the asteroid. However, even these simpler calculations require more time than mission planners can afford when investigating many options for deflecting/disrupting a hazardous asteroid.

Previously, a simple analytic formula was derived by Managan et al. that provided a reasonable approximation to the Δv of some early calculations by J. Wasem. Recent calculations have shown that this formula is inaccurate when *extrapolated* to small standoff distances or higher fluences. Looking at the energy deposition for these higher fluences from the model of Burkey et al. shows that the assumptions that went into the analytic formula are violated at high fluences, so the disagreement is not surprising. This work runs a larger set of hydrodynamic calculations using Burkey et al.'s energy deposition model to see where the analytic formula fails and whether a new fit can be done to extend its range of validity. The formula may also be fitted for

calculations on the other three materials available in the deposition model if time permits. These calculations are being done with the Ares hydrodynamics code. The dimensionless analytic formula for Δv is show in Figure 1 versus the dimensionless standoff distance d/R and the dimensionless fluence $Y/(bd^2)$ where b is the fluence that results in melt at the surface. The black circles indicate Wasem's calculations used to fit the formula and the gray circles are the calculations used in this study. The fluence range matches the range used in determining the model of Burkey et al. The central line of the grid is chosen to match the peak ridge line of the formula and the outer lines are one magnitude away in d/R. These results will allow us to determine whether the analytic formula can adequately represent the physics that occurs at higher fluences.

Figure 1: Dimensionless analytic formula



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Comments:

If possible, an oral presentation would be great. Thank you!