PDC 2019
Washington, DC, USA

Please send your abstract to iaapdc (at) iaamail.org

- [ ] **Key International and Political Developments**
- [ ] **Advancements in NEO Discovery**
- [ ] **New NEO Characterization Results**
- [ ] **Deflection & Disruption Modeling and Testing**
- [ ] **Mission & Campaign Design**
- [ ] **Impact Consequences**
- [ ] **Disaster Response**
- [ ] **The Decision to Act**
- [ ] **Public Education and Communication**

Reradiation of Energy Deposited by X-rays

Robert A. Managan[a,1,*], Patrick K. King[b,2], Kirsten M. Howley[c,1], Joseph V. Wasem[d,1]

[a] *LLNL, P.O. Box 808, L-095, Livermore, CA, 94551-0808, USA, (925) 423-0903*
[b] *Dept. of Astronomy, University of Virginia, 530 McCormick Road Charlottesville, VA 22904, USA, (925) 423-0309*
[c] *LLNL, P.O. Box 808, L-170, Livermore, CA, 94551-0808, USA, (925) 422-9150*
[d] *LLNL, P.O. Box 808, L-031, Livermore, CA, 94551-0808, USA, (925) 423-9232*

Keywords: deflection, disruption, energy deposition, numerical simulations, nuclear

---

Objects on an Earth-impact trajectory can be diverted using nuclear devices, where energy is deposited in the form of x-rays, gamma rays, and neutrons, and the resulting blow-off of the superheated material deflects the remaining object. If the generated shock is strong enough, the target may also be robustly disrupted into smaller fragments. The details of the device spectrum, placement of the device, and composition of the target heavily influence the outcome of these scenarios. Numerical simulations provide a means for studying deflection and disruption effects for a variety of targets and mission parameters. This modeling requires a detailed understanding of the device spectrum, how that energy couples to the material, the response of the material, and the numerical accuracy of the simulation. Improper treatment of any of these components can lead to large inaccuracies.

Not all of the energy coupled to the asteroid is useful in producing blow-off. Soft x-rays deposit their energy into a very shallow layer since the opacity is large and the mean free path is small for 1–2 keV blackbody photons. Also, as the deposition occurs in 0.01–1.0 μs [1] this means that the surface layer can be heated to temperatures greater than 1 keV if the fluence of the source is large enough. At these temperatures radiative energy transport will redistribute the energy before hydrodynamical motion begins, and much of the internal energy can be radiated away before the heated material can blow off. This radiative cooling can significantly reduce the effective delivered yield, and in turn how much blow-off momentum is imparted to the target, as well as the strength of the shock in the target material.

This paper will develop a semi-analytic model to calculate what fraction of the deposited energy remains in the material of the asteroid to produce a shock and blow off the surface layer. First this will be done for an instantaneous uniform deposition and second for one calculated with the Monte-Carlo code Mercury [2]. Analytic models for the “photosphere” are coupled to the rate at which energy is

*Corresponding author
Email addresses: managan1@llnl.gov (Robert A. Managan), king97@llnl.gov (Patrick K. King), howley1@llnl.gov (Kirsten M. Howley), wasem2@llnl.gov (Joseph V. Wasem)
[1] Physicist, WCI/DP Division
[2] Livermore Graduate Scholar, WCI/DP Division

radiated away and a self-similar model of the radiation propagating into the material. Comparison to radiation-hydrodynamic simulations will be done to validate the model.

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-763283.

References

[1] S. Glasstone, P. J. Dolan, The Effects of Nuclear Weapons, United States Department of Defense and the Energy Research and Development Administration, third edition edition, 1977.

[2] P. S. Brantley, S. A. Dawson, M. S. McKinley, M. J. O'Brien, R. J. Procassini, S. M. Sepke, D. E. Stevens, Mercury User Guide:Version d.8, Technical Report LLNL-SM-560687, LLNL, 2012.