PDC 2017
Tokyo, Japan

Deflection & Disruption Modeling and Testing ☑

Strategies for Comet Deflection by Laser Heating

Qicheng Zhang[a,*], Philip M. Lubin[a], Gary B. Hughes[b]

[a] *Department of Physics, University of California, Santa Barbara, CA, 93106, USA*
[b] *Statistics Department, California Polytechnic State University, San Luis Obispo, CA, 93407, USA*

Keywords: comet, laser array, sublimation, nongravitational acceleration, orbital simulation

---

Impact mitigation techniques have been studied extensively for asteroid diversion but often neglect cometary impactors. Asteroid interdiction schemes often involve physically intercepting the target by spacecraft, a task feasible only for targets identified decades in advance following a low eccentricity, low inclination orbit. These qualities are not held by most comets, particularly long-period comets which are often discovered only months before encountering Earth. An alternative method to deflect a comet is to heat it from afar by a laser array, a method particularly well-suited for comet deflection due to the presence of volatile material—particularly water ice—on or near the surface of the target comet. Heating the comet, whether naturally by the Sun, or artificially with a laser, sublimates these volatiles and activates jets of gas and dust which exert thrust on the comet, perturbing its trajectory. Orbital simulations based on observed perturbations by solar heating were previously developed to model the deflection of incoming comets by laser arrays in Earth orbit and on the planet's surface [1]. A 500 m laser array operating at 10 GW for 1% of each day over 1 yr is sufficient to fully avert the impact of a typical 500 m diameter comet.

The short time frame between discovery and Earth encounter implies that a cometary impact threat will likely not have been precisely characterized by the time action is needed. Deflection strategies will be faced with large uncertainties in the comet's physical properties, including its size, structure and composition, as well as in its original orbital trajectory. These uncertainties are modeled, then propagated through the simulations with Monte Carlo methods to analyze the modified impact risk and to estimate the potential effects of associated hazards. One such hazard is the fragmentation of the comet, an event which could be triggered by excessive heating. Fragmentation would preclude a clean deflection, but could be preferable to the impact of a single intact comet if the fragmentation is triggered sufficiently in advance, possibly intentionally if such an impact cannot otherwise be avoided. A related hazard is posed by dust grains released by the comet, which may severely damage artificial satellites. Heating the comet, which increases its level of activity, may elevate these hazards even while reducing the risk of impact itself. Strategies are developed to mitigate various impact threats and these other hazards associated with this method of deflection.

Comments:
We prefer an oral presentation for this abstract.

References

[1] Q. Zhang, P. M. Lubin, G. B. Hughes, Simulations of directed energy comet deflection, in: G. B. Hughes (Ed.), Proceedings of SPIE, volume 9981, p. 998108.

*Corresponding author
Email addresses: qicheng@cometary.org (Qicheng Zhang), lubin@deepspace.ucsb.edu (Philip M. Lubin), gbhughes@calpoly.edu (Gary B. Hughes)