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Using Impact Flash to Initiate Nuclear Explosive Devices in Planetary Defense Missions

Mark Boslough
University of New Mexico, Los Alamos National Laboratory

Russell TerBeek
Sandia National Laboratories

Brin Bailey, Alexander N. Cohen, Philip Lubin
University of California, Santa Barbara

Sasha Egan
New Mexico Institute of Mining and Technology, Energetic Materials Research and Testing Center

Catherine Plesko, Wendy Caldwell
Los Alamos National Laboratory

The problem of asteroid impact mitigation has many solutions, and the optimal answer depends on circumstances. For some missions, a kinetic impact or gentle continuous force (e.g. ion beam or gravity tractor) will suffice. However, if the warning time is too short, or if the asteroid is too large, then only a nuclear detonation will impart the required change in velocity to safely steer the asteroid away from Earth or robustly disrupt in a way that minimizes the probability of impact by dangerous fragments. In this paper, we propose a novel method of reliably fuzing the nuclear explosive device (NED) to prepare it for detonation. This relies upon the phenomenon of impact flash: when an impactor hits a target at high speeds (often exceeding 2 km/s), it produces a high-intensity pulse of light that can be detected at considerable distance. Many laboratory experiments have been performed which characterize the emissions produced by this impact as the impact produces high temperature ejecta and shock waves that travel through both the impactor and target [e.g. Boslough (1985); Ang, (1990)]. This body of work establishes credibility to use an impact flash trigger in a real-world scenario. In practice, the impactor would be a separate spacecraft from the NED module. We can use lidar transmitters and receivers on the impact module, which can be controlled with small thrusters to ensure that it stays a nominal distance ahead of the NED and that it remains at rest in its reference frame. As an example, if the closing speed of the asteroid is roughly 10 km/s, and if the two craft are 100 meters apart, then the impact flash would be detected by the NED 10 ms before it would strike the target. This would provide ample buffer time for the NED to count down and detonate. The brightness and rapid rise time of an impact flash would be difficult to mistake for any other source, and its magnitude can be estimated from theory and tests in order to calibrate the NED's receiver. The advantage of this approach over other systems is that the high impact speeds are guaranteed to generate an impact flash between the impactor and the target. This could be crucial if there is a debris field surrounding the asteroid. It also does not require passive information, such as sunlight collected by optical cameras. Furthermore, this approach would allow the effective prescription of the height of burst in-situ. If the asteroid turns out to be larger than predicted, or if a reconnaissance mission cannot be flown, then this mission type could function as its own reconnaissance. The optimal height of burst could be achieved by the impactor craft's thrusters putting it a little closer to, or a little farther from, the NED, or by resetting the count-down clock interval to prescribe the time between impact and detonation.