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CHARACTERIZING THE IMPACT OF ROTATIONAL VELOCITY ON A LASER-BASED DEBRIS REMOVAL SYSTEM

Abstract

Space debris presents a threat to orbital craft and must be located and, in some cases, removed. Lasers may prove to be an ideal method for doing this. Their benefits include being able to operate at a distance from the debris and the ability to potentially make use of a theoretically infinite supply of energy from the sun. Lasers are also a well-understood and readily available technology.

This paper proposes and evaluates a laser-based space debris removal system. It explains how the system would operate and characterizes the benefit and drawbacks of such a system. One key consideration is that lasers may not be able to remove all debris, however, as a debris item's rotational velocity may impair the ability of a laser-based system to remove it from orbit. The problem takes two forms. First, the rotational velocity increases the surface area over which the laser is projected, thus decreasing its intensity and ability to thermalize the surface and create meaningful velocity change. Second, rotational velocity may reorient the ejecting material, impairing the utility of the change in orbital velocity produced. Understanding the effect of rotational velocity on laser debris removal is a key part of fully understanding the efficacy of a laser-based debris removal system.

This paper proposes a method for testing the effects of rotational velocity on the performance of a laser-based space debris removal system. Several tests are reported on. First, a test to characterize the importance of eliminating rotational velocity from debris is discussed. This test was conducted using a vacuum chamber, high speed camera, remote trigger, high intensity pulse laser, and simulated debris. The debris has been simulated using polystyrene. Its low density allows the effect produced to be more pronounced and more easily measured. Experiments were initially conducted using spherical simulated debris. A variety of irregular shapes were also tested, and the impact of the debris having an irregular shape have been characterized.

The experimental procedure included suspending the debris within the vacuum chamber. The laser was aimed at the debris. After the air is evacuated, the remote trigger mechanism is used to impart a spin to the simulated debris. The pulse laser is applied to the debris and the high-speed camera is used to film the interaction. For each debris item, the process is repeated without imparting spin and the data from the spinning and non-spinning trials are compared.