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Pulsed Laser Ablation Propulsion of Asteroids: Time-of-Flight Mass Spectrometry and Direct Force Measurements

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ABSTRACT

Laser ablation is a promising technology for asteroid mitigation. A laser is fired at the Earth-threatening asteroid by a nearby spacecraft, generating a plasma plume that produces thrust. Since the asteroid itself serves as the propellant, no additional propellant is needed for redirecting the asteroid outside of station-keeping.

Research has been conducted at the University of Maryland Space Power and Propulsion Laboratory to study the propulsion performance of pulsed laser ablation of asteroid analogues. A 1064 nm laser with a 0.7 ns pulse width, and 817 μJ per pulse, is fired at asteroid analogues in vacuum, and the resulting ablation plume is analyzed. An energy gated time-of-flight mass spectrometer is used to characterize the ablation plume from firing the laser at pyroxene rock. From this, a two dimension

distribution of the plasma ions is constructed, as a function of both speed and mass-per-charge. The specific impulse of the ions was found to be 6920 s. Since this does not measure neutrals or larger particles, it overestimates the overall performance.

For a more direct measure of performance, the thrust is measured using a Novatech F329 Deci-Newton Loadcell. The thrust is measured over 500 ms with the laser firing at 40 kHz. In addition to pyroxene, the thrust measurements are conducted on high-fidelity simulants for CM, CR, and CI asteroids, developed by Deep Space Industries and the University of Central Florida. The average momentum coupling coefficients for the various materials were measured. This demonstrates the effectiveness of laser ablation, as well as providing a critical measurement for the design of an asteroid redirection mission.

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