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Directed Energy Deflection Laboratory Measurements of Common Space Based Targets

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ABSTRACT

We report on laboratory studies of the effectiveness of directed energy planetary defense as a part of the DE-STAR (**D**irected **E**nergy **S**ystem for **T**argeting of **A**steroids and explo**R**ation) program. DE-STAR [1][5][6] and DE-STARLITE [2][5][6] are directed energy "stand-off" and "stand-on" programs, respectively that come out of a NASA funded Innovative Advanced Concept Grant and Breakthrough Initiative Project, Breakthrough Starshot. These systems consist of a modular array of kilowatt-class lasers powered by photovoltaics, and are capable of heating a spot on the surface of an asteroid to the point of vaporization. Mass ejection, as a plume of evaporated material, creates a reactionary thrust capable of diverting the asteroid's orbit. In a series of papers, we have developed a theoretical basis and described numerical simulations for determining the thrust produced by material evaporating from the surface of an asteroid [1][2][3][4][5][6]. In the DE-STAR concept, the asteroid itself is used as the deflection "propellant". This study presents results of experiments designed to measure the thrust created by evaporation from a laser directed energy spot. We constructed a vacuum chamber to simulate space conditions, and installed a torsion balance that holds a common space target sample. The sample is illuminated with a fiber array laser with flux levels up to 60 MW/m^2, which allows us to simulate a mission level flux but on a small scale. We use a separate laser as well as a position sensitive centroid detector to readout the angular motion of the torsion balance and can thus determine the thrust. We compare the measured thrust to the models. Our theoretical models indicate a coupling coefficient well in excess of 100 $\mu N/W_{optical}$, though we assume a more conservative value of 80 $\mu N/W_{optical}$ and then degrade this with an optical "encircled energy" efficiency of 0.75 to 60 $\mu N/W_{optical}$ in our deflection modeling. Our measurements discussed here yield about 45 $\mu N/W_{absorbed}$ as a reasonable lower limit to the thrust per optical watt absorbed. Results vary depending on the material tested and are limited to measurements of 1 axis, so further tests must be performed.

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