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SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Concepts (6)

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LASER ABLATION FOR SPACE DEBRIS MITIGATION

Abstract

Reducing space debris hazards is necessary to stabilise the space environment and control the growth of future debris populations, especially in Low Earth Orbit (LEO). Removing space debris by lasers has been investigated as a possible approach for the contactless deflection of space debris in LEO. It can be achieved by irradiating the space debris with a high power laser beam. The interaction between the laser irradiance and the surface of the debris produces surface power intensities that cause sharp temperature increases which leads to non-equilibrium energy transport. The absorbed energy from the laser sublimates the surface of the orbital debris, transforming the illuminated material directly from a solid to a gas. The evaporated material then forms into a plume of ejecta which acts against the orbital debris and produces a small thrust due to the momentum force. This small thrust reduces the orbital velocity of the space debris and eventually lowers its altitude and thus its life-time in orbit. The potential for reducing space debris by lasers is dependent upon understanding the interaction technique and the ablation operation including the surface temperature variation of the space debris material and the energy absorption within the evaporation layer.

In this article, the interaction process has been studied and the laser ablation model is developed and used to simulate the growth of the spatial temperature distribution by illuminating three different types of metals, namely: aluminium; nickel; and copper, with a pulsed Nd^{3+} Glass laser operated at wavelength of 1.06 μm. The viability of this ablation model and its performance in inducing a deflection action has been studied. The average mass flow rate of the ablated ejecta is predicted and the power required to reduce the orbital velocity of the debris and its altitude are calculated.

The outcomes of this paper describe the possibility for space debris mitigation with lasers. The paper enhances the ablation model, which is based on the energy equilibrium of sublimation. The performance of this ablation technique was assessed by its power to deorbit a small piece of space debris of 1-10 cm diameter. The effectiveness of this low thrust deflection approach exceeded the performance of other forms of contact mitigation methods, which have the attendant risk of creating more orbital debris.