EXPERIMENTAL ANALYSIS OF LASER ABLATION FOR ASTEROID DEFLECTION AND EXPLOITATION

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Asteroids, the leftover debris from planetary formation, represent both an opportunity and a risk. Their pristine environment captures the early impact evolution of the solar system, whereas their impact risk could result in the mass extinction of life. This is considered to have happened once before, approximately 65 million years ago, with the mass extinction of the dinosaurs. It will happen again. It is only a matter of time. However, novel techniques are now being developed to mitigate and assess the impending asteroid-to-Earth impact risk. Specifically, asteroid deflection through laser ablation is considered to be a promising mitigation technique. This is achieved by irradiating the surface of an asteroid with a laser light source. The resulting heat enables the surface rock to ablate, transforming the material directly from a solid to a gas. The ablated material then expands to form an ejecta plume. Over an extended period of time, this provides a continuous and controlled force that can be used to actively deviate small to medium size asteroids.

To fully examine the laser ablation approach a series of self contained experiments have been performed. The aim was to examine the formation and evolution of the ejecta plume, and the associated rates of ejecta contamination. This is in a continued effort to determine whether or not laser ablation is an effective and achievable method of deflecting asteroids. A 90 watt laser was used to initiate the ablation response. All experiments were conducted within a vacuum chamber. Two different asteroid analogue target materials were tested – a dense solid sample and a highly porous sample. This was used to represent the diversity within the asteroid population. Results to date have assessed the thermal influences – the surface spot temperature and the volumetric heating of the sample, - and the mass flow rate, velocity and divergence of the developing ejecta plume. The deposition and associated contamination of any optical surface within the local vicinity of the ejecta plume has also been examined.

Compared to the numerical model, considerably less contamination has been observed. This will, critically, affect the lifetime of the mission and the achievable rates of asteroid deflection. The experiment has therefore provided both validation and calibration of the current theoretical model and existing theory. Furthermore, and of most significance, is that the experiment has demonstrated the diversity of using laser ablation for a range of space based missions. The experiments have revealed that laser ablation is effective in the successful extracting and analysis of the target material's subsurface composition. Laser ablation, therefore, does not only offer itself as an effective method of asteroid deflection, but also as a contact-less method for the potential exploitation, exploration and analysis of asteroids, and other rocky bodies. Work has been performed in collaboration with the Advanced Concept Laboratory, University of Strathclyde, the Institute of Photonics, University of Strathclyde, the Planetary Society and the Mechanical Engineering department, University of Glasgow.