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SURVEILLANCE AND MITIGATION OF ORBITAL DEBRIS: LASER SYSTEMS AND STANDARDS

Abstract

The threat posed by orbital debris is international in character. Any attempt at solution will affect all space faring nations. Lasers used for surveillance in space from locations in space offer measurement capabilities that approach fundamentally limited precision. Unlike use of lasers on Earth, attenuation, dispersion and fluctuations caused by Earth's atmosphere do not compromise the use of the necessary laser minimum uncertainty optical states. We model, e.g., measurement and mitigation strategies useful for debris elements too small to be observed from Earth. We make a case that laser systems offer not only improved means of surveillance, but also precise means of repositioning and deorbiting debris. Laser pulse induced ablation of material from a given piece of debris is more than adequate for repositioning and, given a sufficiently large number of pulses, deorbiting small debris elements. We provide analyses showing the power needed for surveillance and repositioning is orders of magnitude below laser weapons levels. There is a valid concern that altering the orbit of even a small piece of debris to reduce the threat to a given spacecraft can increase the threat to other spacecraft. We suggest that a precisely articulated set of standards is important. The UN Committee on the Peaceful Uses of Outer Space (COPUOS) could consider such standards and methods. We consider first steps for such efforts. As regards surveillance methods, ultrashort laser pulses in space offer means of locating debris with a precision approaching fundamental limits. Frequency stabilized lasers offer measurement of the magnitude and direction of debris velocity with a precision traceable to atomic clocks. The shapes of objects, period of rotation, scattering coefficients, moments of inertia and other properties of debris elements are also measurable with similarly high precision. By way of a prototypical experiment we consider use of lasers, e.g., to warn and protect astronauts on the International Space Station (ISS) against threats posed by space debris. This experiment resembles the larger task of defending human life on Earth against asteroids and comets. This ISS effort could provide a global laboratory for developing relevant international procedures and laws. Such agreements may someday be valuable in encouraging a unified addressing of greater dangers, such as those posed by near Earth objects (NEOs) large enough to threaten all of human life.