SPACE DEBRIS SYMPOSIUM (A6)
Measurements (1)

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HIGH-POWER OPTICAL PHASED ARRAYS FOR SPACE DEBRIS TRACKING AND MANOEUVRING

Abstract

Space debris (defunct satellites, fragments, rocket bodies) is a growing threat to near-earth space activities. This has motivated the development of viable techniques to track space debris for precise determination of its orbital trajectory, allowing functioning satellites to move out of its path. But this is only a temporary solution to a problem that is expected to escalate as the number of space debris in orbit is anticipated to grow exponentially according to the Kessler Syndrome—a runaway chain reaction of collisions that will render low-earth orbit unusable. It is therefore necessary to explore realistic techniques such as ground-based lasers to remove or at least manoeuvre space debris.

The sensitivity of existing space debris tracking systems can be improved by directing more light onto target using an optical phased array (OPA) to coherently combine multiple lasers. Increasing the optical power even further may also permit remote manoeuvring of space debris via photon radiation pressure and/or ablation—a capability that at this stage has not been demonstrated using conventional systems. In contrast to incoherent laser combination, an OPA actively controls the relative phase of multiple lasers, forming a contiguous and coherent optical wavefront in the far field. As a result, the peak intensity of the coherently combined beam scales as the square of the number of lasers in the array (N^2), compared to incoherent combination. OPAs are therefore able to support higher total delivery of power to a point in the far field beyond the limits of conventional lasers, without significant penalty on beam quality and cost.

We present an OPA architecture capable of supporting high-power operation (> 1 kW), that has been designed to improve the sensitivity of an existing ground-based space debris tracking system in Australia, and potentially enable space debris manoeuvring. The ability to control each emitter independently is

achieved using digitally enhanced interferometry, which isolates the phase information from each emitter using a form of code division multiplexing—a technique used in GPS and mobile phone systems. A key feature of our approach is internal sensing, where we derive all control signals from the small fraction of light reflected back into the fiber at the output of the OPA. A proof-of-concept system has recently been tested in the lab, demonstrating excellent coherence in the far-field and quadratic scaling of intensity at the central interference lobe.