High-Power Amplifier Compatible Internally Sensed Optical Phased Array for Space Debris Tracking and Maneuvering

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Optical phased arrays (OPAs) provide a way to scale optical power beyond the capabilities of conventional CW lasers via coherent beam combination. By stabilising the relative output phase of multiple spatially separate lasers, OPAs form a coherent optical wavefront in the far field. Since the phase of each laser can be controlled independently, OPAs also have the ability to manipulate the distribution of optical power in the far field, and therefore may provide the capability to compensate for atmospheric turbulence. Combined with their inherent scalability and high power handling capabilities, OPAs are a promising technology for CW space debris ranging and manoeuvring.

The OPA presented here is unique in its ability to sense the phase of each laser internally, without requiring any external sampling optics between it and the telescope. This allows the internally sensed OPA to be constructed entirely within fibre, utilising high-power fiber amplifiers to scale optical power beyond the limits of any conventional single lasers. The total power that can be delivered by each emitter in the OPA is limited only by the onset of stimulated Brillouin scattering, a non-linear effect that clamps the amount of power that can be delivered through a fiber waveguide.

A three element internally sensed OPA developed at the Australian National University has been demonstrated to coherently combine three commercial 15 Watt fiber amplifiers with an output phase stability of one 200th of a wavelength. We have also demonstrated the ability to dynamically manipulate the distribution of optical power in the far-field at a bandwidth of up to 10 kHz.

Since the OPA's control system is implemented using field-programmable gate-array technology, the system may be scaled beyond 100 emitters, potentially reaching the kilowatt level optical powers required to perturb the orbit of space debris.