Developing Optical Phased Array sensing for the Breakthrough Starshot propulsion system

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Optical Phased Arrays (OPA) with a sufficient size and number of sub-apertures may provide an ideal platform for ground-to-space laser transmission in the future. They can provide increased power transmission beyond the limits of individual lasers through coherent beam combination, direct actuation of the outgoing wavefront for steering and atmospheric correction as well as supporting large emitting areas for small spot sizes in orbit.

The Breakthrough Starshot program proposes the use of a laser system based on the power and control afforded by OPAs for the propulsion of a sail-based space craft (sailcraft) to Alpha Centauri [1]. In the case of a terrestrial laser system, this system requires steering and correction for atmospheric turbulence and power requirements in the order of 100 GW over several minutes. This exceeds currently demonstrated OPAs and is far beyond the capabilities of existing laser technology. One potential avenue to meet these requirements is to coherently combine multiple OPAs.

In designing an array for such a mission [2], we have explored several configurations of our proposed hierarchical OPA system. We present the key considerations for using optical interferometry to phase-lock arrays of different sizes up to the 100 million emitters needed for the Breakthrough Starshot system. This is accompanied by modelling that assesses the technological requirements of components that would be needed; including why this architecture requires the use of multiple sensing wavelengths to function effectively.

[1] K.L. Parkin, *Acta Astronautica* **152**, 370-284 (2018).

[2] C.P. Bandutunga, P.G. Sibley, M.J. Ireland and R.L. Ward, *JOSA B*, **38**(5), 1477-1486 (2021).