New applications of Adaptive Fiber-Optics Collimator in Fiber Coupling and Beam Pointing*

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Abstract—We report two kinds of new applications of adaptive fiber-optics collimator, a wavefront tip/tilt corrector, in fields of fiber coupling and beam pointing, respectively.

Keywords—adaptive fiber-optics collimator; beam combining; fiber coupling; beam pointing

To compensate the tip/tilt aberrations in beam combining of fiber laser array, a new-style corrector named adaptive fiber-optics collimator (AFOC) was developed and used in experiments by M. A. Vorontsov’s team [1] and our team [2], respectively. As depicted in Fig. 1, the AFOC contains a lens and a fiber-tip positioner which consists of a cross-beam and four bimorph piezoelectric actuators. The applied driving voltages induce actuators bend and force the cross-beam with the fiber tip to translate $\Delta X$ in the focus plane of the lens. The correctable tip/tilt angle $\theta$ of laser beam is due to $\Delta X/f$. In fact, based on the principle of optical reversibility, the AFOC has the capability of beam bi-directional control (collimating and/or coupling). Other than beam combining, we report two kinds of new applications of AFOCs in fields of fiber coupling and beam pointing, respectively.

Fig. 1. Schematic of AFOC with the capability of beam bi-directional control

We verified the reversal application of AFOC for adaptive fiber coupling. A uniform plane-wave beam with 1064nm wavelength is sent to a fast-steering mirror which is used to introduce angular jitters. Then, the laser beam is coupled by the AFOC and sent to a photodetector (PD). Stochastic parallel gradient descent (SPGD) algorithm is employed as the control strategy, where the detected power from the PD is used as metric function, and the algorithm’s iteration rate is 625Hz. In closed loop, coupling efficiency keeps above 65% when angular errors are below 80$\mu$rad. The compensation bandwidth is 35Hz at sine-jitter of 15$\mu$rad amplitude with average coupling efficiency of above 60%. Fig. 2 plots the evolution curve of fiber coupling efficiency with a kind of sine angular jitter with frequency of 2Hz and amplitude of 30$\mu$rad.

Fig. 2. Evolution curve of fiber coupling efficiency with a sine-jitter

Another kind of application of AFOC is in laser beam pointing area, where the AFOC is used as beam launching and boresight-error correcting device. Beam pointing setup with a laser propagation distance of 200m through horizontal atmosphere is established. The aperture of measured beam on target is 40mm, and the target is an aluminum block with a diameter of 18mm. Based on returning signals from the illuminated target, the beam-pointing closed loop using SPGD algorithm is achieved under different initial boresight errors. Fig. 3 is the snapshots of beam-pointing results in open loop and closed loop, respectively. Experimental results tell that the evaluation parameter of the residual boresight errors is less than 10.8%, which is within the tolerance of theoretical analysis.

Fig. 3. Snapshots of beam-pointing results in (a) open loop and (b) closed loop using AFOC

Fig. 1. Schematic of AFOC with the capability of beam bi-directional control

References


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