Wavefront sensing based on fiber coupling of the fiber laser array

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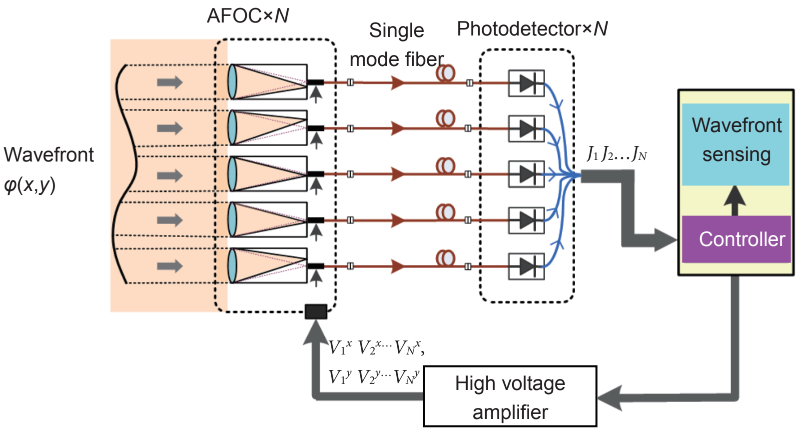

Scheme of the wavefront sensor based on adaptive fiber optics collimator array

Overview: Coherent beam combining (CBC) of fiber amplifiers with a master-oscillator-power amplifier (MOPA) architecture is a promising way for brightness scaling with excellent beam quality. Fiber laser array, as a typical CBC architecture, has been widely applied in laboratory experiments. Further application aims at eliminating the turbulence-induced dynamic aberrations. The correctable aberrations of the fiber laser array are tip/tilts and pistons distribute on the sub-aperture. Target-in-the-loop (TIL) technique cooperating with optimal method is the only way reported to achieve CBC in atmosphere. Such method suffers from low bandwidth due to large array scale and long air path. Active detecting the atmospheric aberrations becomes necessary. Conventional wavefront sensor, like Hartmann-Shack, needs beam zooming and splitting in the back end of the telescope. Direct spatial beam zooming and splitting in the back end of fiber laser array system is impossible because the system is discrete in space. Meanwhile, setting a splitter large enough to cover the whole array aperture is inconceivable and breaks the compact and flexible character of the fiber laser array architecture. A new method of wavefront sensing based on fiber coupling in the fiber laser array has been proposed. The scheme and the recovery process of this sensor are introduced. Numerical simulations of detecting the turbulence-induced aberrations utilizing such method and experiments of recovering static aberrations with 7-element AFOC array are presented. Numerical results show that such sensor could effectively recover the wavefront with turbulence-induced aberrations. For hexagonal array with different units, the optimum reconstructed Zernike mode is also different. Smaller array filled factor leads to larger recovery residual error. Compared with array filled factor of 1.0, value of 0.8 is easy to obtain and brings in recovery residual error increment less than 10%. Experimental results reveal that RMS less than 0.075 μm of the recovery residual error is obtained when detecting the static aberration with 7-element AFOC array with filled factor of 0.875. The aberration is with RMS of 0.433 μm and mainly includes Zernike modes of low orders like defocus. Results here validate the effectiveness of the wavefront sensing method proposed. Such method would get further application in systems like laser array propagating and turbulence aberrations correcting.

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