Vector Zernike Wavefront Sensor Development: On-Sky and Laboratory Segment Co-Phasing Results

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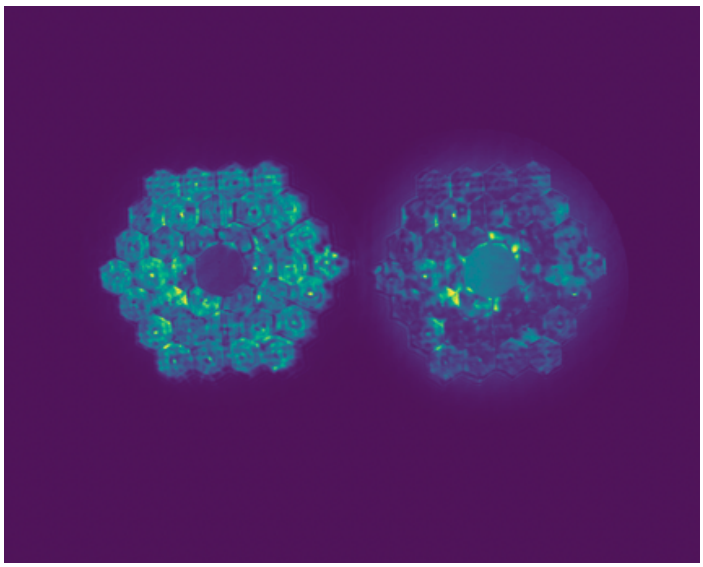
We demonstrate segment position sensing and control on Keck II telescope's primary mirror using the vector-Zernike wavefront sensor. Segment co-phasing errors are a primary contributor to contrast limits on Keck and will be necessary to correct for the next generation of space and ground-based ELTs, which will all have segmented primary mirrors. The Zernike wavefront sensor (ZWFS) is ideal for measuring phase discontinuities from co-phasing errors in a segmented telescope and the low wind effect, as well as sensing non-common path aberrations. It consists of a focal plane mask which imposes a phase offset to the core of the PSF, which then interferes with the remaining PSF, converting phase variations to intensity variations in the pupil image. The vector-Zernike mask imposes two different phase offsets to orthogonally polarized light, producing two pupil images. Compared with the traditional scalar ZWFS, the vector-ZWFS has a superior dynamic range and enables the reconstruction of the wavefront's amplitude as well as phase. We evaluate the performance of these vector-Zernike WFSs in measuring and correcting segment co-phasing errors in the presence of atmospheric turbulence on-sky at Keck and with simulated atmospheric turbulence in the lab on the Santa Cruz Extreme AO Lab (SEAL) testbed and discuss the results in the context of high contrast imaging.



Caption: On-sky 30-sec images taken with the vector-ZWFS installed in the Keck Planet Imager and Characterizer (KPIC). Our goal is to reduce segment co-phasing errors by measuring and correcting individual segment piston, tip, and tilt.