Towards On-Sky Focal Plane Wavefront Control of Residual Atmospheric Speckles

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Abstract

Ground-based adaptive optics (AO) technologies have advanced to the point of enabling direct detections of some gas-giant exoplanets, but leftover wavefront errors, realized as "speckles" in the coronagraphic science image, still limit instrument sensitivities to detecting lower-mass, closer-in, and/or older/colder exoplanetary systems. Improving AO wavefront sensors (WFSs) and control is a critical approach to improving AO-assisted instrument sensitivity for science cases such as exoplanet imaging. Here we present results from ongoing developments of high-speed focal plane wavefront sensing and control techniques on the Santa Cruz Extreme AO Laboratory (SEAL) testbed. We demonstrate "multi-WFS single conjugate AO," correcting for deformable mirror (DM)-simulated full-scale atmospheric turbulence for using a Shack Hartmann WFS operating at up to 400 Hz combined with a focal plane WFS operating at up to 100 Hz to control a woofer and tweeter DM via a custom real-time control architecture. Demonstrating this multi-WFS architecture also opens up applications to other flavors of WFS "fusion" (e.g., simultaneous Pyramid and Shack Hartmann WFS operations).

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