National Aeronautics and Space Administration

FY25 Strategic University Research Partnership (SURP)

Evaluation of Spatial Light Modulator (SLM) for High Contrast Imaging

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Background:

- To image Earth-like exoplanets with the proposed Habitable Worlds Observatory (HWO), >10,000 wavefront correction modes are desired.
- State-of-the-art deformable mirrors (DMs) used on Roman CGI and ground telescopes have only 950-4100 actuators.
- Spatial light modulators (SLMs) are an intriguing alternative with <u>>100,000 active pixels</u> in a compact form factor.
- Graduate student Jennifer Bragg at UofA has built a coronagraphic testbed and has been characterizing an SLM for use in high-contrast imaging.

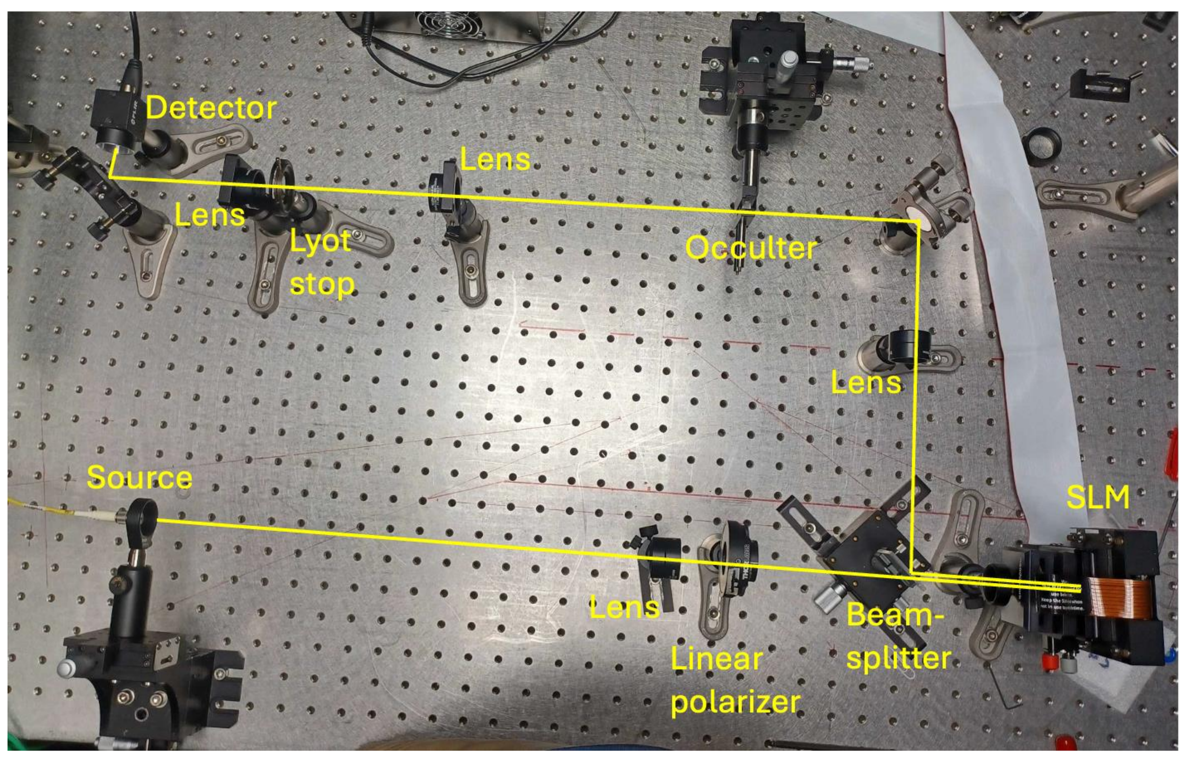

Figure 1: Version 2 of the SLM testbed.

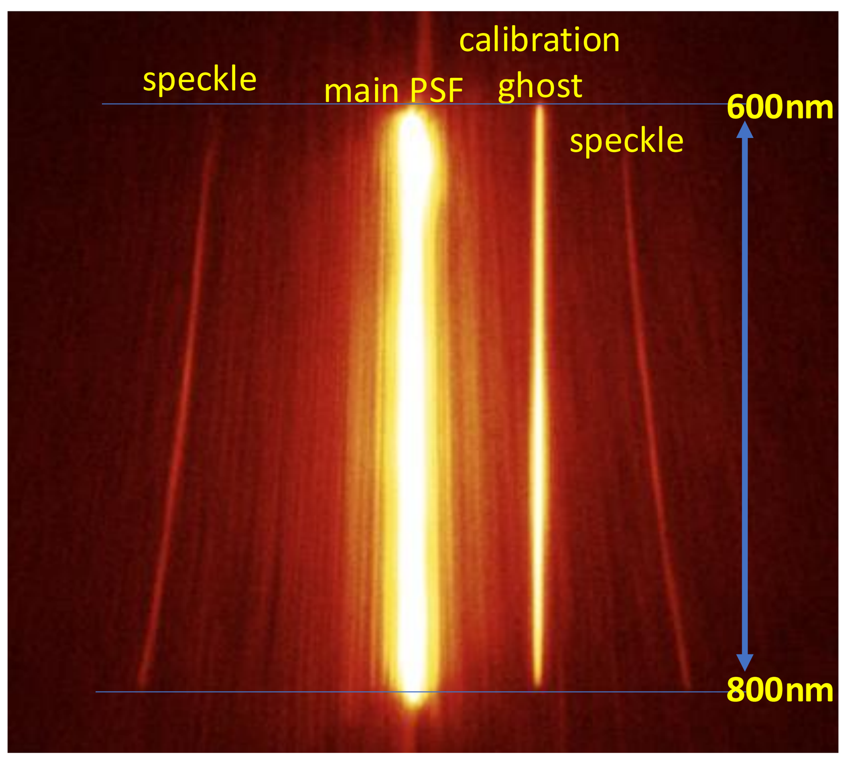

Figure 2: Prism-dispersed image.

Objectives:

- Characterize a liquid crystal SLM at moderate contrast in three key risk areas for a space mission:
  1) **stability**, 2) **chromaticity**, and 3) **polarization**.
- Perform wavefront sensing and control with the SLM and a Lyot coronagraph.

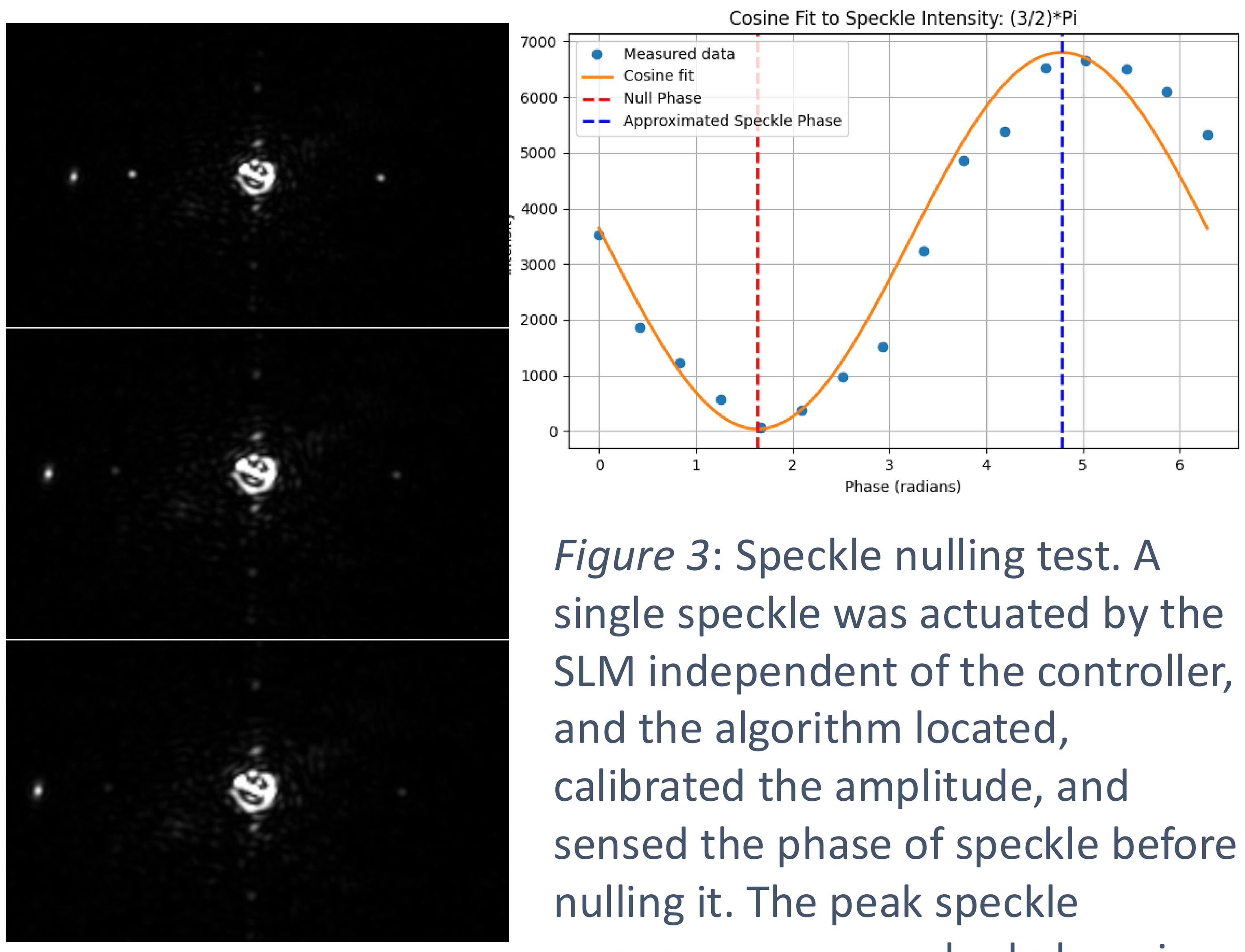

Figure 3: Speckle nulling test. A single speckle was actuated by the SLM independent of the controller, and the algorithm located, calibrated the amplitude, and sensed the phase of speckle before nulling it. The peak speckle response versus probed phase is shown on the right, and images for three different probe phases are shown on the left.

Approach and Results:

- The two main facets of our research this year were 1) to characterize the SLM at better contrast in version 2 (v2) of the optical testbed built last year, and 2) to demonstrate wavefront control with the spatial light modulator (SLM). The v2 testbed includes a simple Lyot coronagraph to improve our raw contrast and measurement sensitivity by two orders of magnitude compared to our initial tests in year 1. We performed all the SLM characterization with a broadband SuperK laser in its brightest visible output range from 600-800 nm.
- Our results show that the SLM performance is good enough to merit further testing at higher contrast on an in-air, thermally stabilized coronagraphic bench.

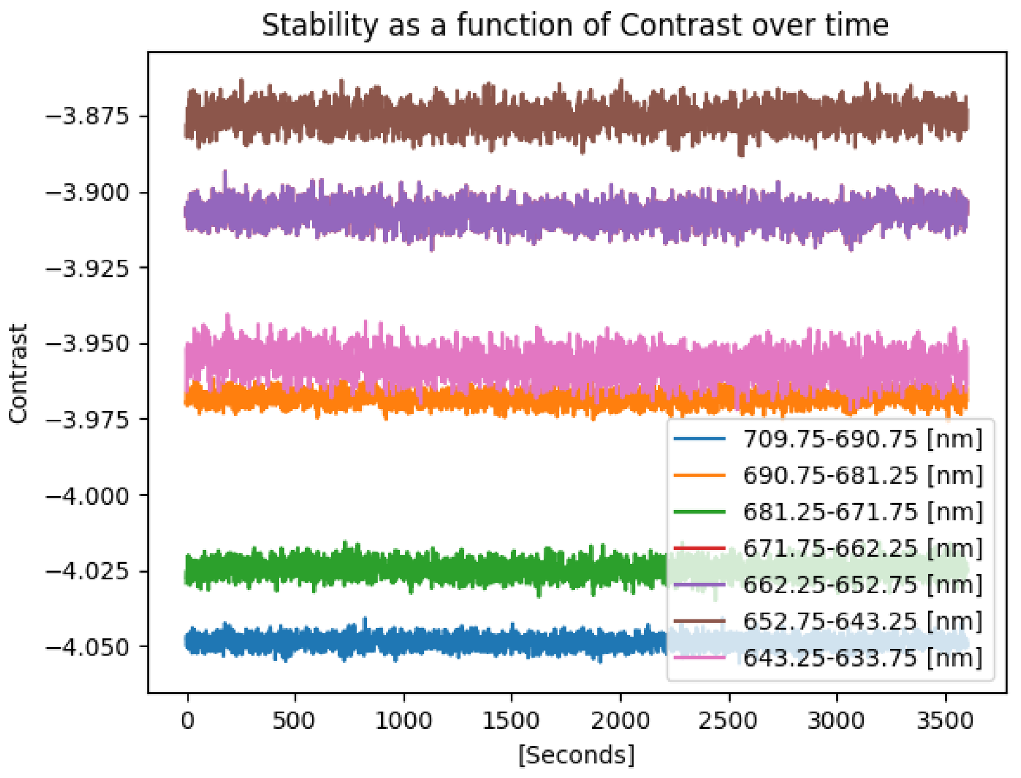

Figure 4: Stability measurements of the SLM-actuated speckles in the focal plane. The ratio of the actuated speckle and an intentional, faint ghost of the PSF is used to remove systematic errors in the laser power. The 1% noise level appears to be shot noise.

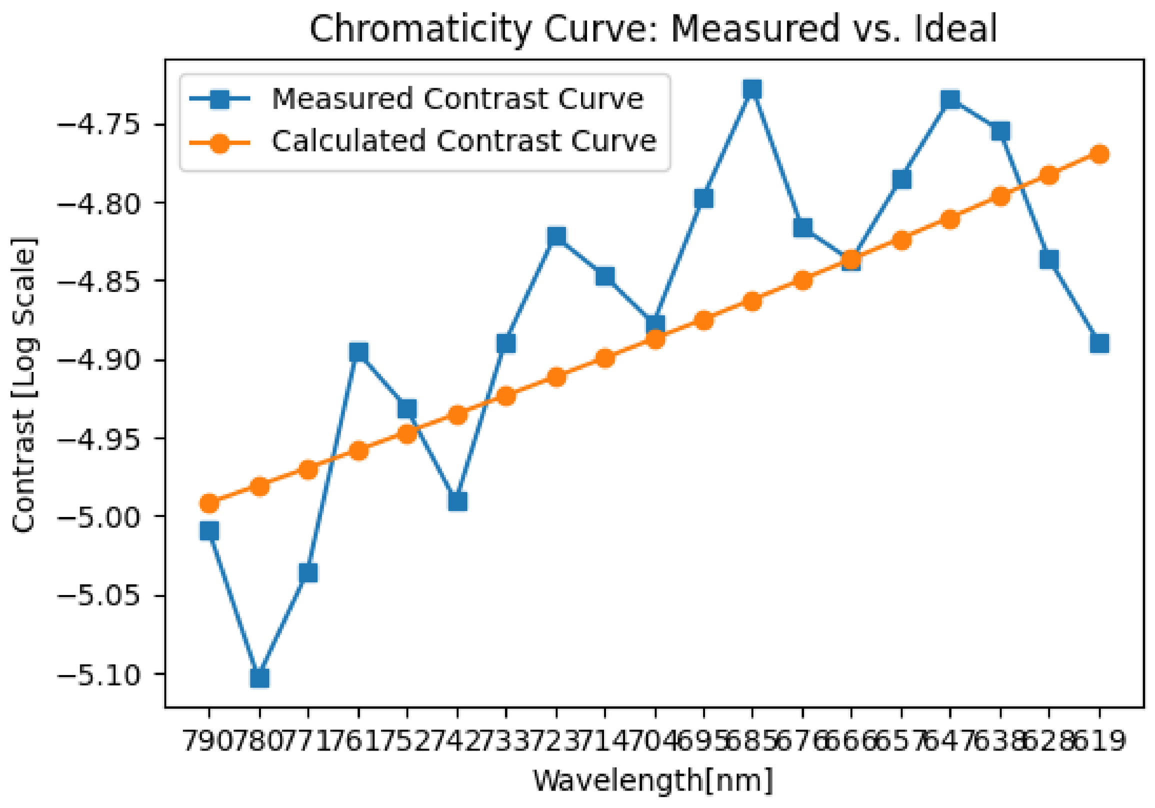

Figure 5: SLM chromaticity. The wavelength^{-2} relationship of an ideal, achromatic optic (such as a mirror) is the curve in orange, and the measured response of the SLM-actuated speckle is in blue. Other than some noise, the SLM fits the achromatic response curve well over the 600-800 nm wavelengths tested.

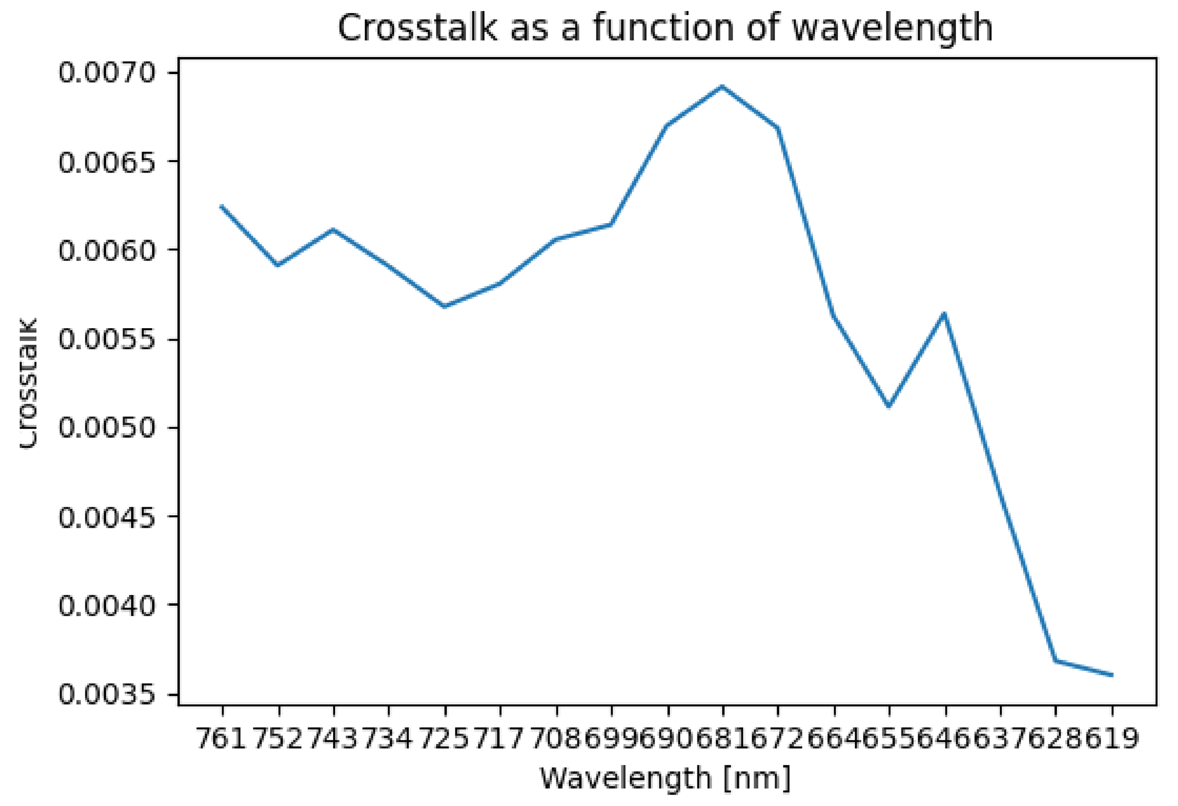

Figure 6: Polarization crosstalk of the SLM-actuated speckle was measured to be between 0.3% and 0.7% in the perpendicular polarization state.

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Benefits to NASA and JPL:

JPL has been a leader in developing coronagraphic technologies for over two decades. To continue leadership in coronagraphy for NASA's proposed HWO flagship mission, JPL should continue to advance technologies to address the NASA APD Tier 1 Gap List items of coronagraph stability and coronagraph contrast and efficiency. This project's SLM research effort keeps JPL at the forefront of wavefront correction technology development.