First System-level Demonstration of High-Contrast for Future Segmented Space Telescopes
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The search for life is one of the next great challenges in astronomy. NASA's 30-Year Roadmap for Astrophysics envisions a search for signs of life in the atmospheres of Earth-like planets using spectroscopy from a large space telescope. NASA is now pursuing three flagship concept studies that will enable this search (LUVOIR, HabEx, and OST). Estimates for the number of Earth-like planets such a mission can detect and characterize increase as the second power of the aperture, motivating telescopes larger than JWST that must be segmented to fit into anticipated launch fairings. It is certain that a mission capable of directly imaging Earth-like exoplanets will include a coronagraph, even if starshades prove to be effective and feasible. Thus, the technological challenges presented by high-performance coronagraphy on segmented telescopes must be solved if we are to mount a statistically robust search for life on other worlds.

Our group's testbed, HiCAT, is dedicated to developing high-performance coronagraph technology for segmented apertures, using our Apodized Pupil Lyot Coronagraph (APLC) approach. By optimizing individual components, we have matured the technology to TRL 3. But for a segmented telescope aiming to achieve 1e-10 starlight suppression, the stability of the wavefront delivered from the telescope presents special challenges to coronagraph performance. The telescope and coronagraph must be considered together and their technologies advanced as an integrated system.

This proposal will support us in taking the next logical step in segmented coronagraph technology, achieving TRL 4 first at the component level, then TRL 4 in a full-system context. Our roadmap intentionally parallels the plan for advancing coronagraphs on monolithic apertures to higher TRLs for WFIRST CGI: Coronagraph designs are first demonstrated in a static environment before integrated tests of the full wavefront control system in dynamic contexts. Maturation of technologies on a flexible ambient testbed sets the stage for advanced demonstrations in vacuum.

Our roadmap to raise the system-level TRL for high-contrast coronagraphy on segmented apertures will require the following major technical tasks:

1. Ongoing advancement of the shaped-pupil APLC as an individual component, including refinements to mask designs, hardware optimization and tolerancing, and understanding of the impacts of segment-level aberrations.
2. Advancing the readiness of the integrated system, with the coronagraph and a multi-layered wavefront control system working together to sense and correct for dynamic instabilities on the spatial and temporal frequencies of interest in a segmented observatory.
3. Refining and validating performance models for segmented coronagraphy over a range of spatial and time scales, both to directly support the prior two tasks, and to provide improved modeling capabilities for future vacuum tests and mission design studies.

Our roadmap will achieve component-level TRL 4 by the end of 2019, during the deliberations for the 2020 Decadal Survey. System-level TRL 4 is planned for mid-2021. This current stage of our plan focuses on advancing technologies as rapidly as possible in air on our HiCAT testbed. Working in ambient conditions has greater flexibility to make rapid advances, refine models with a wider range of component tests, and quickly respond to new findings. Once we have achieved TRL 4 in air, it will be optimal to move to vacuum for higher TRL demonstrations. Our work will directly mature components and algorithms for tests with the JPL "Decadal Survey Testbed'', which is only now beginning. Our close connections with JPL will make this transfer smooth. In this larger context, the work proposed here will provide a clear path to mature technology and help enable a mid-2020s new start for a mission that will search for life on other worlds.