National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Optimization and System Integration of Photonics for Advanced Astrophysics Mission Concepts

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Strategic Focus Area: Photonics | **Strategic Initiative Leader:** Charles Lawrence

Objectives:

Develop a photonic component design, fabrication, and test capability leading to instruments on the critical path to infusion in future astrophysics missions.

- Iterative development cycle: Inverse design, fabrication, and test
- Construction of photonics testbed facilities for end-to-end instrument development

Background:

Key 7x challenges enabled:

- Focal plane wavefront sensing and control for segmented apertures
- Near-ideal small inner working angle coronagraphs
- High resolution, high throughput photonic spectrographs

Approach and Results:

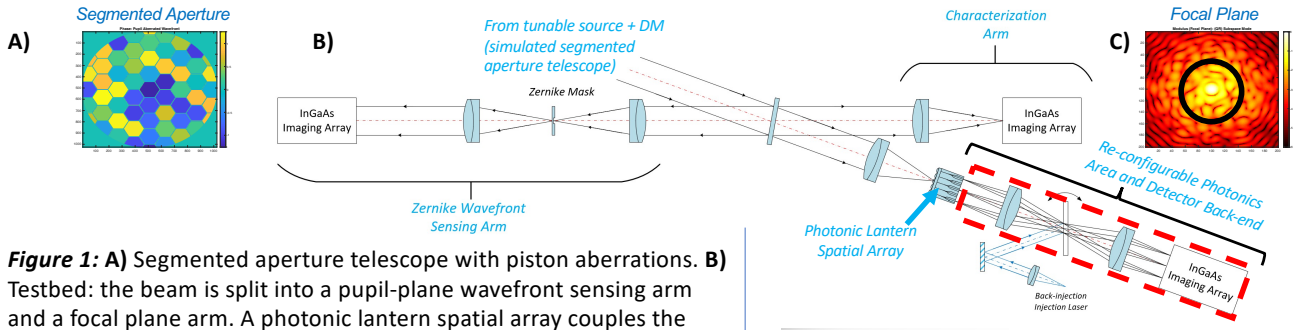
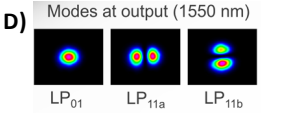


Figure 1: **A)** Segmented aperture telescope with piston aberrations. **B)** Testbed: the beam is split into a pupil-plane wavefront sensing arm and a focal plane arm. A photonic lantern spatial array couples the free-space incident light, with single-mode waveguide outputs for downstream coupling to photonic devices. **C)** The incident focal plane field from the aberrated aperture as shown in *fig. 1A*. The region inside the black circle couples efficiently to the photonic lantern spatial array.



Riesen et al, DOI:10.1038/s41598-017-06561-w

Figure 1D: Each lantern in the spatial array couples to the LP modes as shown, giving a local modal decomposition of the incident field.

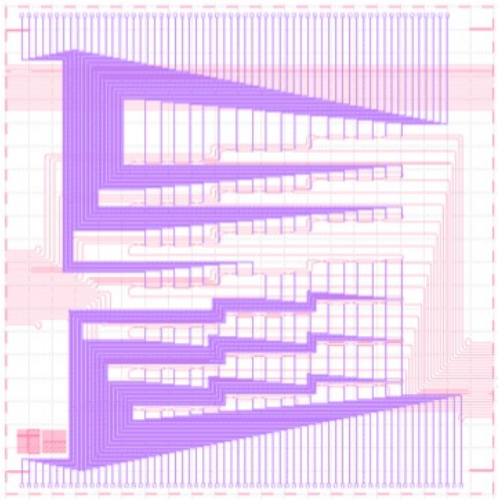
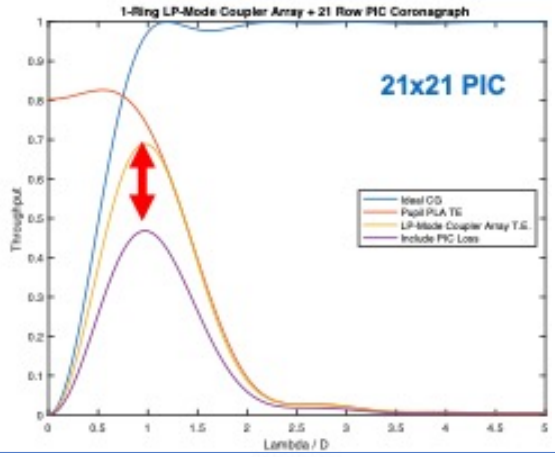


Figure 1E. Dynamic Photonic Integrated Circuit (PIC), with 21 input and output waveguides, capable or sorting an arbitrary mode with all the light in that mode output on one channel. The PIC can be integrated into the back end of the lantern array in figure 1B, providing an end-to-end photonic coronagraph.

Significance/Benefits to JPL and NASA:

- Photonic coronagraph concept has the potential to achieve *near ideal performance* for exoplanets very close to the host star
- Directly addresses the key science goal of the Astrophysics Decadal *Habitable Worlds Observatory* mission concept



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Clearance Number: CL#00-0000
Poster Number: RPC#

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