# Dual-purpose coronagraph masks for enabling high-contrast imaging with an IR/O/UV flagship mission

**J. Kent Wallace (JPL/Caltech), PI**

The recently released Astronomy Decadal report is impressive in its endorsement of the search for and detection/characterization of exoplanets. In particular, the report endorses a flagship, space-based telescope to specifically address this ambitious science goal.

However, we should be mindful that there are serious technical challenges presented by the ambitious goal of high-contrast imaging. In particular, optical quality and stability of the full optical beam train of the observatory – from collecting aperture to science focal plane – is required. Specifically, the total contribution of the wavefront errors must be stable at the 10 pm level over the several tens of minutes. This is very difficult.

Thankfully there is good news. Over the past decade, NASA has been investing resources into the technical development of wavefront sensing in support of high-contrast imaging, and it has yielded great success. In particular, the Zernike Wavefront Sensor (ZWFS) has been integrated into the focal plane mask of a stellar coronagraph to enable low-order wavefront sensing (ie., pointing jitter, focus, astigmatism). This low-order ZWFS has been demonstrated to meet the sensing and control requirements using faint photon fluxes typical of many science observing scenarios. Separately, a dedicated ZWFS has also been demonstrated to measure mid- to high spatial frequencies with exquisite sensing capabilities at the picometer level, with precision limited only by the quantum fluctuations of photon-noise.

Here we propose to extend this technology in the following way: the Zernike wavefront sensor will be modified to work: 1) with photons not in the science band 2) to measure both low- and high-spatial frequencies and 3) to do so contemporaneously with high contrast science observations. The dual-purpose focal plane mask (combining wavefront sensing and coronagraphy) will greatly relax the observatory requirements. Using this dual-purpose focal plane mask capability, we fundamentally change the picometer wavefront requirement from being a stability problem to being a sensing and control problem. This affords a significant relaxation in the observatory requirements.

Our plan is to develop dual-purpose focal plane masks, experimentally demonstrate these masks first for high-contrast imaging, then subsequently for wavefront sensing, and finally for contemporaneous science and sensing with active, closed-loop wavefront control. The goal being to maintain high-contrast in the science focal plane while sensing and controlling wavefront quality using out-of-band photons.