THE WFIRST CORONAGRAPH INSTRUMENT. N. Zimmerman[1] , N. J. Kasdin[2], V. Bailey[3], J. Rhodes[3], M. Turnbull[4], B. Macintosh[5], J. Trauger[3], B. Mennesson[3], M. Frerking[3], R. Zellem[3]
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Introduction: The Wide Field Infrared Survey Telescope (WFIRST) is a flagship NASA space telescope mission in the preliminary design phase. The primary instrument payload of WFIRST is the Wide Field Instrument (WFI), designed to conduct large near-infrared sky surveys, measure the effects of dark energy, and detect new populations of exoplanets via gravitational microlensing. The second instrument in the payload is the Coronagraph Instrument (CGI), whose purpose is to demonstrate technologies for future space missions aiming to directly image exoplanets [1].

In contrast to the WFI, the CGI will operate at visible wavelengths in a narrow field of view. The CGI will debut several critical technologies in space to enable the > 100× leap in starlight suppression performance needed to image and characterize exoplanets in visible-wavelength, reflected starlight.

Critical Technologies: CGI will be the first instrument on a space telescope to make use of numerically optimized, precision-fabricated coronagraph masks; large-format deformable mirrors for high-order wavefront control; a low-order wavefront sensing and control system; and electron-multiplying CCD (EMCCD) detectors for low-flux photon counting [2]. The advanced algorithms needed for the operation of multiple control loops and for data processing also constitute novel elements which will prove valuable pathfinders for future missions. The WFIRST Project has invested in an extensive technology maturation effort to develop and test prototypes on engineering testbeds, in particular with system-level starlight suppression demonstrations on JPL's High Contrast Imaging Testbed [3].

Observing Modes: In order to execute a compelling demonstration of its critical technologies on astrophysical sources, CGI will have the capability to switch between three observing modes: (i) broadband imaging with a Hybrid Lyot Coronagraph with inner working angle 3 λ/D in a 546—604 nm bandpass; (ii) a Shaped Pupil Coronagraph for spectroscopic imaging with a lenslet-based integral field spectrograph, at spectral resolving power R=50 in a 675—785 nm bandpass; (iii) a Shaped Pupil Coronagraph for broadband imaging of debris disks at separations ranging 6—20 λ/D in a 784—866 nm bandpass. All of these observing modes are designed to reach a flux ratio sensitivity requirement of 5×10^{-8} including margins and model uncertainty factors. Error budget predictions indicate CGI may reach flux ratio sensitivities down to ~ 5×10^{-10} in imaging (100 hr, V=5), and ~ 4×10^{-9} in spectroscopy (400 hr, V=5) [4].

Potential for Scientific Operations: The current WFIRST Science Investigation Teams are composed primarily of experts from the academic community outside of NASA and are essential to defining the requirements and demonstration objectives of CGI. These teams will be in place through 2021. Current plans call for the WFIRST project to solicit external experts to help execute the technology demonstration via a Participating Scientist Program. If instrument performance warrants it, these participating scientists may perform science operations beyond the 18 month technology demonstration period [5].

References:

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