

## FY24 Strategic Initiatives Research and Technology Development (SRTD)

# **ULTRASTABILITY FOR CORONAGRAPHIC TELESCOPES**

Principal Investigator: David Redding (383); Co-Investigators: Scott Basinger (383), Brandon Dube (383), Jeff Jewell (398), John Lou (383), Gene Serabyn (3262), Erkin Sidick (383 retired), Jonathan Tesch (383); Collaborators: Marie Levine (383), Kent Wallace (326)

Strategic Focus Area: Starlight Suppression | Strategic Initiative Leader: David W Miller

**Objective:** Prepare for the **Habitable Worlds Observatory** (HWO) – a new NASA flagship project that will use a coronagraph instrument to discover and characterize exoplanets, especially exoEarths.

**Background:** Coronagraphs use Masks, Stops and Deformable Mirrors to suppress the light from stars, so that much dimmer planets orbiting the stars can be seen. Coronagraphic telescopes require extreme optical precision and stability to do this.

Approach and Results: Models of the HWO Exploratory Analysis Configuration-1 (EAC-1) were built and used to design sensing and control architectures that can provide coronagraph contrast stability of 10<sup>-12</sup> for days at a time.

Significance/Benefits to JPL and NASA: JPL technologies, with further development, will be able to provide the stability needed for the HWO project.

#### HabWorlds Exploratory Analysis Configuration-1

A 4-mirror telescope with a pupil-correcting relay into the coronagraph. Beamsplitters separate the beam into four nearly-identical coronagraphs, by polarization and wavelength (UVIS/NIR).



#### **External Metrology:** Laser Trusses and Edge Sensors





- External Metrology uses laser distance gauges and segment edge sensors to stabilize the telescope optics with respect to the back end and the Internal Metrology light source
- Internal Metrology uses a bright out-of-band internal source and wavefront sensors in the coronagraph to stabilize the optics past the telescope secondary mirror

#### WFE and Contrast: Configurations 1, 5 and 6



#### Internal Metrology: Internal Source and Coronagraph WF Sensing



•Out-of-Band WF sensors can measure the full complex field at the Coronagraph entrance pupil, and drive both DM1 and DM2, for best contrast control

**National Aeronautics and Space Administration** 

#### **Jet Propulsion Laboratory**

California Institute of Technology Pasadena, California

#### www.nasa.gov

Clearance Number: CL#24-5064 **RPD-000** 

Copyright 2024. All rights reserved.

### **Publications:**

- [A] J. Lou, D. Redding, S. Basinger, B. Dube, J. Tesch, A. Kee, C. Nissly, M. Troy, "Habitable world observatory modeling optical and metrology models, and performance predictions," SPIE 13129-22 (2024).
- [B] B. Dube, H. Nejadriahi, E. Sidick, J. Jewell, D. Redding, J. Lou, S. Basinger, "Absolute and differential complex E field reconstruction by phase shifting interferometry," SPIE 13092-178 (2024) https://doi.org/10.1117/12.3020656.
- [C] D. Redding, S. Basinger, S. Bikkannavar, B. Dube, A. Kee, J. Lou, C. Nissly, C. Ohara, P. Poon, E. Sidick, J. Tesch, M. Troy,
  - "Wavefront sensing and control for a future Habitable Worlds Observatory," SPIE 130921P (2024), https://doi.org/10.1117/12.3020583.
- [D] D. Redding, "EAC-1 Sensing and Control Architecture," HWO TAG Configuration Report, 6/27/2024.
- [E] D. Redding, S. Basinger, J. Lou, E. Sidick, J. Tesch, "EAC1 Sensing and Control Architecture and Technologies," HWO TAG Technology Study Report, 5/15/2024.
- PI contact information: David.C.Redding@jpl.nasa.gov; 818-354-3696

- Edge Sensor STD (pm) 1. MET with all Laser Trusses, and Gap, Pistor with all Laser Trusses, but only Gap 5. MET with 10 Laser Trusses, and Gap, Piston and Shear Edge Sensor measurements and Shear Measurement Edge Sensor measureme • Objective: keep Delta Contrast to 10<sup>-12</sup> or smaller • Configuration 1: 120 Laser Gauges, 84 Edge Sensors measuring piston, gap, shear <sup>-</sup> Meets 1e-12 *dCb* if  $\sigma_L$  < 8 pm and  $\sigma_{ES}$  < 6 pm or  $\sigma_L$  < 4 pm and  $\sigma_{ES}$  < 35 pm • Configuration 5: 60 laser gauges, 84 Edge Sensors measuring piston, gap, shear <sup>-</sup> Meets 1e-12 *dCb* if  $\sigma_L$  < 8 pm and  $\sigma_{ES}$  < 3 pm or  $\sigma_L$  < 4 pm and  $\sigma_{ES}$  < 5 pm
- Configuration 6: 120 Laser Gauges, 84 Edge Sensors measuring gap only
- <sup>-</sup> Meets 1e-12 *dCb* if  $\sigma_L$  < 4 pm and  $\sigma_{gap}$  < 10 pm or  $\sigma_L$  < 2 pm and  $\sigma_{gap}$  < 23 pm

HabWorlds Path Forward: Project Office formed at GSFC on August 1, with JPL participating in project leadership. Technology development phase extends through ~2030, with launch ~2040.