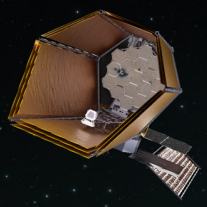


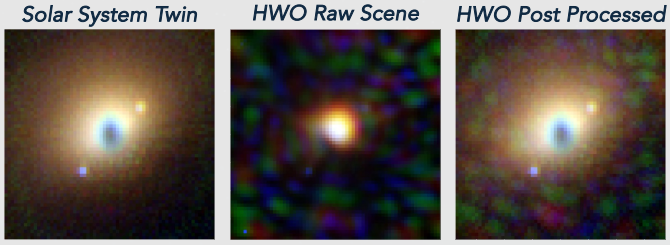
Habitable World Discovery and Characterization: Coronagraph Concept of Operations and Post Processing (COPP)

Michael W. McElwain, Dimitri Mawet, Roser Juanola Parramon, Kellen Lawson, Hervé Le Coroller, Christian Marois, Max Millar-Blanchaer, Bijan Nemati, Susan F. Redmond, Bin Ren, Jean-Baptiste Ruffio, Laurent Pueyo, Christopher Stark, & Scott Will

Overview

- The HWO COPP Working Group was established to evaluate coronagraph concept of operations (ConOps) and post-processing techniques for habitable world discovery and characterization [1].
- Science requires ~10^{-10} raw contrast for Earth-analog detection and 1σ photometric precision of ~10^{-12}.
- Focus groups studied COPP state of the art, instrument capabilities required, ConOps, simulated data needs, and analysis approaches.[2]

High Contrast Post Processing is Necessary for HWO

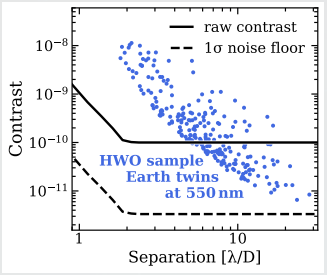


Credit: Corey Spohn (GSFC NPP), Chris Stark (GSFC), Neil Zimmerman (GSFC), Fang Shi (JPL), + HWO IM team

- Idealized coronagraph simulation with the perfect first exploratory architecture, EAC1, using a vector vortex coronagraph clearly shows Earth and Venus.
- The HWO raw scene speckles are from telescope wavefront errors, instabilities, and imperfections in the coronagraph.

Post Processing Improves Discovery Space

- Raw contrast is set by the coronagraph and observatory system.
- Noise floor is imposed by a combination of photon noise, astrophysical noise, contrast stability, and detector noise.



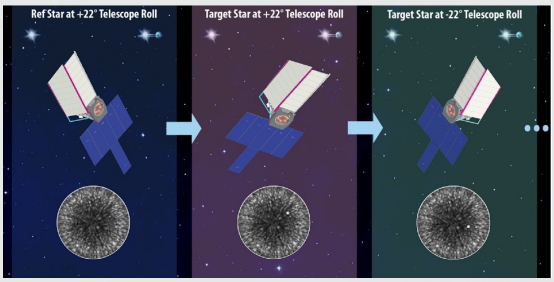
Post Processing Options

- Operational methods
  1. Reference Star[3]
  2. Angular[3]
  3. Exoplanet orbital motion[4]

  Delayed measurement
- Instrument capabilities
  4. Coherence[5]
  5. Spectral[6]
  6. Polarization[7]
  7. Model-based[8]

  Simultaneous measurement

Coronagraph Concept of Operation

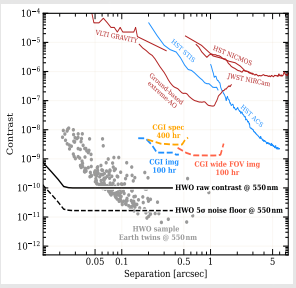


Credit: Simulated data based on HWO Integrated Modeling results provided by John Krist.

- HWO Observing Scenario (OS 1) motivated and error budgeted from the Roman/CGI OS 11[9].
- HWO OS2 includes dark hole generation on reference followed by continuous pointing on target star.

Post Processing Technology Development Needed

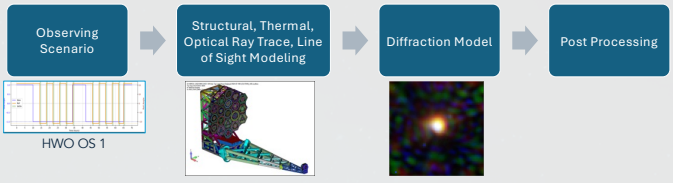
- HWO will operate at contrasts more than 10x deeper than current facilities.
- HWO Technology Plan[10] includes post-processing.
- Opportunities for community participation forthcoming.



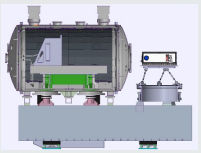
Credit: Kellen Lawson & Vanessa Bailey

Post Processing Demonstrations

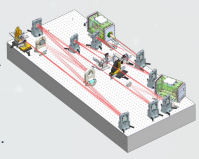
1. Analysis: High-Fidelity Integrated Modeling[11]



2. Tests: Validating Integrated Models[12]



Ultrastable Testbed "Mini-MUST" at NASA Goddard will be used to test 1 m articles at picometer levels.



High contrast imaging demonstrations at JPL on quasi-static "DST2R" (left) and stabilization testbeds. HWO testbed data archive to be made publicly available.

References

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HWO COPP White Papers