Wavefront calibration testing of the James Webb Space Telescope primary mirror center of curvature optical assembly

Gene Olczak, Conrad Wells, David J. Fischer, Mark T. Connolly
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Cryogenic Optical Test Configuration of JWST

Center of Curvature Optical Assembly (COCOA)
- Interferometer, null, calibration equipment
- Coarse/fine PM phasing tools
- Displacement Measuring Interferometer

• Absolute Distance Meter
Ray tracing of the system for finite conjugates with the primary mirror (PM) as the object reveals the interferometer imaging properties.
Imaging Performance In Test

Single Pass: PM to Sensor

Double Pass Objective Back Focus to Objective Back Focus

- The test system has little distortion and diffraction limited imaging performance
System Wavefront Test (SWFT) i.e. Calibration

- During calibration the imaging performance is significantly degraded.

Imaging the Asphere to the interferometer Pupil (first pass)

Reflective CGH inserted at paraxial focus for calibration
Method discussed by Zhao and Burge (Reference 3)

- Analysis predicts more loss of pupil detail at the inner pupil at mid to high spatial frequencies
The Imaging SWTF (I-SWFT)

Objective Lens

Reflective Null

Imaging Lens

CGH

WMS Entrance Port (Pupil Image)

Path Without Imaging Lens

Path With Imaging Lens

Redesigned CGH is easier to fabricate than the baseline CGH
• 10% Smaller
• 33% Lower maximum line density
• 2.9 times less aspheric

- A lens in the calibration path forms a pupil image on the CGH
  - Diffraction limited pupil imaging performance is restored
  - New complication of characterizing and aligning the lens
Initial Testing

- Initial testing performed at a clean assembly facility (Micro Automated in Rochester, NY)
  - Not at optical test facility
  - Vibration was okay
  - Temperature variations well beyond interferometer operation range
    - Much larger than in-use case
Model Versus Measured Performance

Precision in radial normalization is important for interpretation of data for radius and conic estimation.
Test Results by Spatial Frequency

- Low spatial frequency error: largely trefoil
- Mid spatial frequency error: largely asphere stitching artifacts
- High spatial frequency error: largely asphere tooling marks
- Difference between SWFT and I-SWFT: largely spherical aberration
Concluding Remarks

- Initial tests of the JWST COCOA have been completed
- Results to date show good agreement with optical/mechanical models
- As built performance of the null meeting the wavefront error budget
- Testing in controlled ambient and vacuum environments is ongoing
  - Calibration methods for fusing SWFT and I-SWFT data will be refined using updated test results