Searching for Planets and Exozodiacal Emission around the Closest Sun-like Star αCen A with JWST/MIRI

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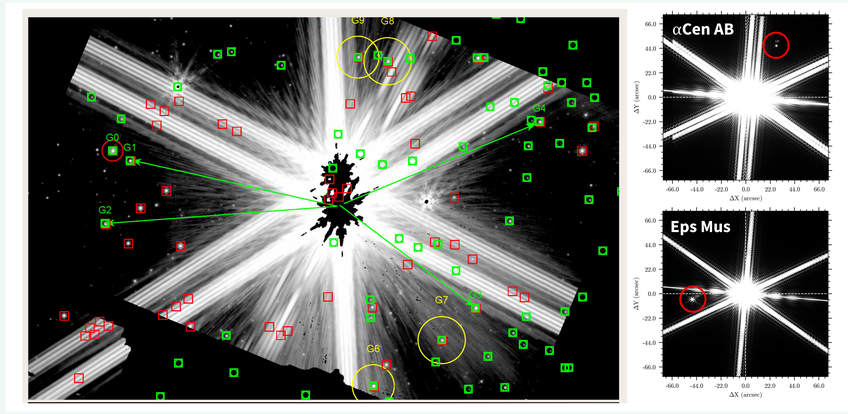
Simulations with on-sky data show that JWST/MIRI can directly image ≳4 R_{Earth} planets heated by αCen A at ~1 au and detect zodiacal disk emission as low as 5 times the level in our Solar System.

Introduction

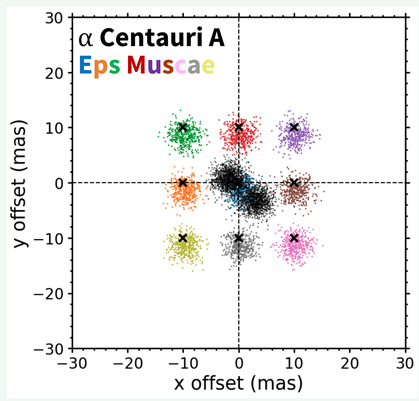
- α Centauri A is closest solar type star (1.33 pc) with a Habitable Zone (1–3 AU; 0.7-2”) resolvable by JWST/MIRI.
- 44-hour Cycle 1 program (PID #1618) for MIRI coronagraph @ 15.5 μm planned for August 2024:
  - Best star-planet contrast for cool planets heated by α Cen A (250–350 K).
  - Lowest impact of wavefront drift and background stars.
  - Post-processing for <10^{-5} contrast.
  - 5-10% probability of finding a 0.5-1 Jupiter radius planet.
  - RV limit <50–100 M_{Earth} from 1-3 AU (Zhao et al. 2018).
- Challenges:
  - Rapidly changing α Cen AB positions due to proper motion and parallax (~10 mas/day; from ALMA astrometry, Akeson et al. 2019).
  - Target acquisition (TA) via blind offsets from Gaia stars.
  - Residual brightness from α Cen B.

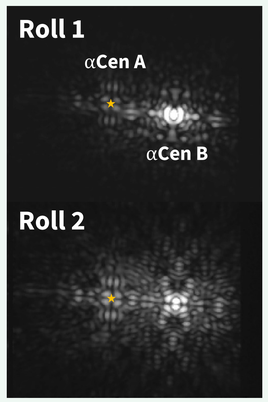


Left: June 2023 F1000W MIRI image showing Gaia stars (red) and MIRI detections (green) of αCen AB field with candidate offset stars (G0-9) for the observation marked. *Right:* Simulated scene with offset stars chosen for the August 2024 observation at the two roll angles of observation.

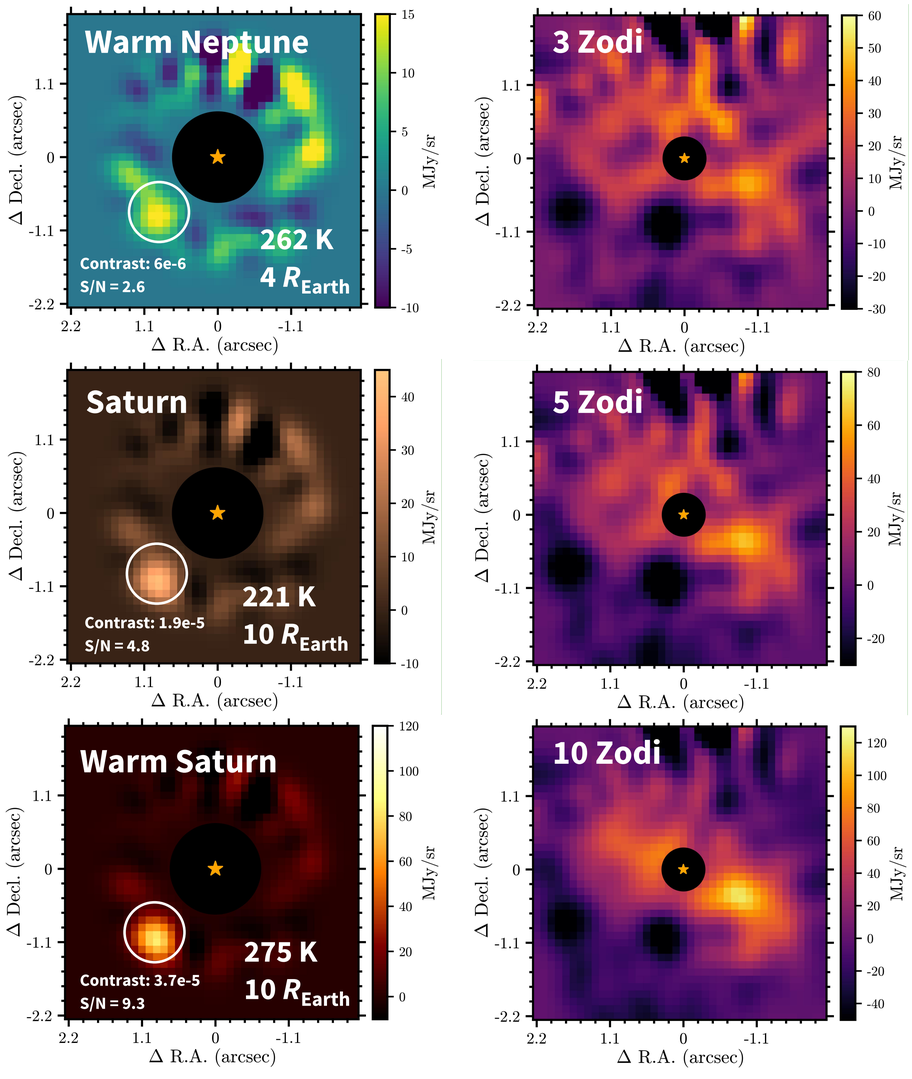
WebbPSF Simulations with July 2023 On-sky Observations

- WebbPSF simulations combined with on-sky MIRI integration sequences show post-processing contrasts of ~10^{-5} at >0.5”.
- Complete sequence of α Cen AB (~5 hours) + partial sequence of Eps Mus reference star (~18 hours) observations carried out by MIRI in July 2023 but suffered TA failures.
- Realistic simulation by inserting PSFs of α Cen AB and background source S2 (Kervella+2016) at expected positions in July 2023 MIRI dataset.
  - Used the closest measured on-sky optical path difference (OPD) map and accounted for pointing error + frame-to-frame jitter to generate α Cen AB target PSFs and Eps Mus reference PSFs.
  - Injected three classes of planets (Beichman et al. 2020) at ~1 au and a PSF-convolved exozodi disk model at different surface brightness levels.
  - PSF subtraction with reference star differential imaging (RDI) recovers the planets and disks: primary limitation is imperfect subtraction of α Cen B.



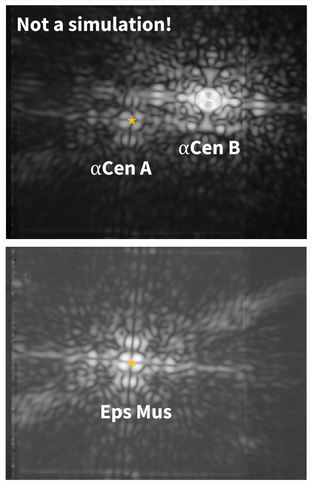


Left: Dither map behind the FQPM coronagraph for simulated αCen A PSFs (black) and Eps Mus PSFs (colored). *Right:* Simulated scene at the two roll angles of observation.

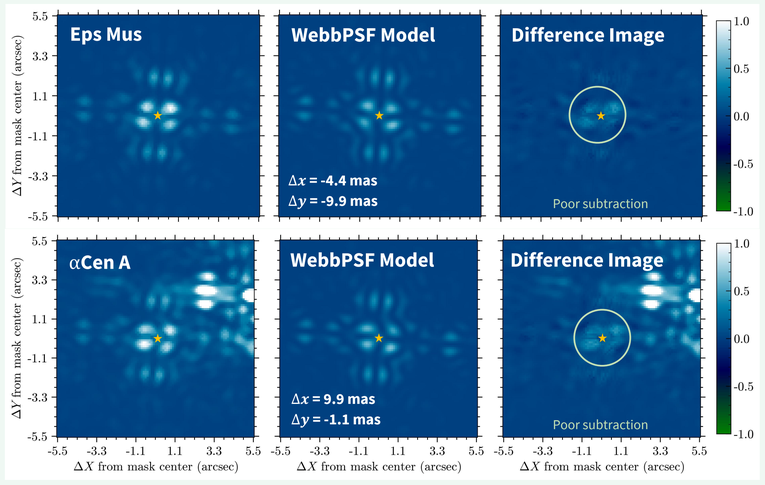


Results from New On-sky Test Observations of αCen AB

1. Target acquisitions via blind offsets were successful!



2. χ^2 minimization-based fitting with a WebbPSF library finds that the error in star position behind mask is <10 mas for both Eps Mus and αCen A.



3. WebbPSF modeling of αCen B is challenging due to distortion effects.