Recent Contrast Measurements Made Using the PICTURE Visible Nulling Coronagraph

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ABSTRACT

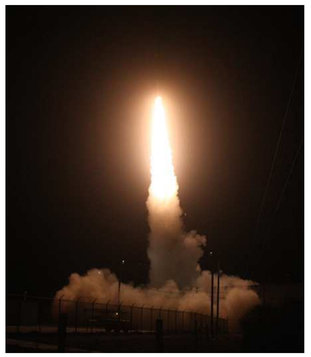
The PICTURE (Planetary Imaging Concept Testbed Using a Rocket Experiment) sounding rocket will use a visible nulling interferometer to characterize the exozodiacal dust disk of Epsilon Eridani (K2V, 3.22 pc) in reflected visible light to an inner radius of 1.5 AU (0.5Ó) from the star. Launch is scheduled for Fall 2014 and the PICTURE payload is currently undergoing refurbishment. The first launch of PICTURE suffered a science telemetry failure and the primary mirror was shattered upon landing; the second launch will fly a new SiC primary mirror and onboard data storage. PICTURE visible light observations will constrain scattering properties of the Epsilon Eridani exozodiacal dust disk from 600nm to 750 nm, measuring the background brightness which must be overcome for future exoplanet observations. Additionally, PICTURE will demonstrate operation of a MEMS deformable mirror and a visible nulling coronagraph in space. We present the latest measurements of interferometer performance.

Mission Properties

Telescope	0.5 m, f/12.3 Gregorian
Nuller	Visible Nulling Coronagraph, 600-750 nm, shear of 0.15m
Science and Wavefront Sensing CCDs	1024x1024 pixel, back-illuminated CCDs from Astro-E2 X-ray mission
Inner & Outer Working Angles	1.5λ/d (0.5") & 5"
Pointing System	Tip-Tilt steering mirror, >5 mas pointing (Mendillo et al. 2012a)

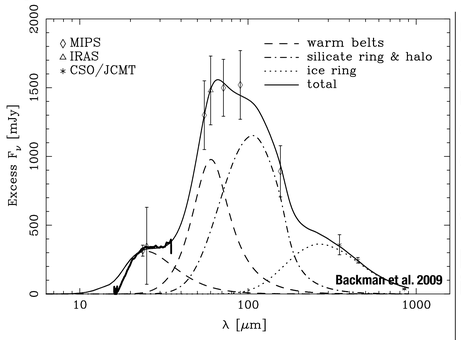
Observing Plan

TARGET	Observing Time	Purpose
Rigel	60 Sec	Demonstrate nulling, record reference PSF
εEri, Roll 1	>105 Sec	Characterize Exozodi
εEri, Roll 2	>105 Sec	Characterize Exozodi and track speckles



The first PICTURE launch in October 2011. (Courtesy WSMR.)

Epsilon Eridani Debris Disk:



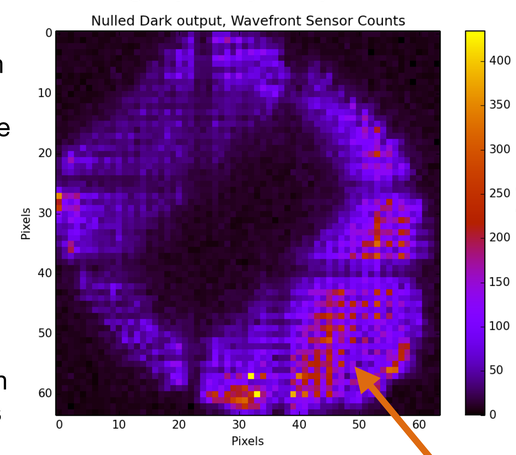
- Epsilon Eridani's spectral energy distribution (SED) shows a significant flux excess (data points, above) at 24um and beyond, indicating a warm ring within 10AU.
- From the SED, Backman et al. (2009) infer a system of rings, lines above, with a thin ring near 3AU, scattering starlight with an expected integrated brightness of $2*10^{-4}$ F_*.

Preliminary Measurement of Nuller Performance in White Light (30 May 2014)

Previously, the PICTURE interferometer's starlight suppression (contrast ratio) has been measured in monochromatic laser light (Rao et al. 2008) to be on the order of ~1/600 at the central star and 1e-4 in the science region.

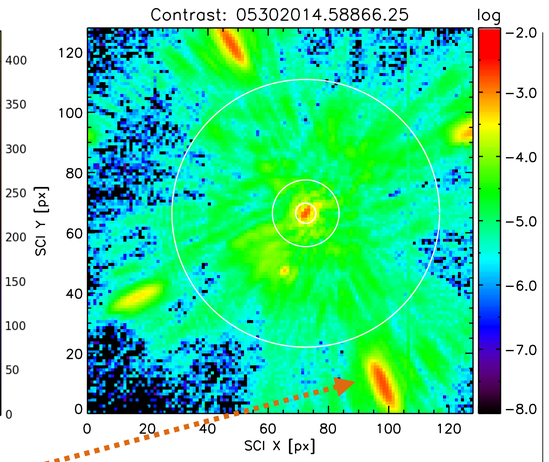
We have measured comparable nuller performance in white light with the following improvements:

- White light injected through a crystal fiber simulates ~10-15% bandwidth, coupled with a spliced multimode input fiber which allows monitoring of input brightness while nulling.
- A new instrument test enclosure and a pneumatic optical bench suppress air currents and high frequency vibrations
- Measurements with the flight science and wavefront sensor cameras



Wavefront Sensor Intensity Map

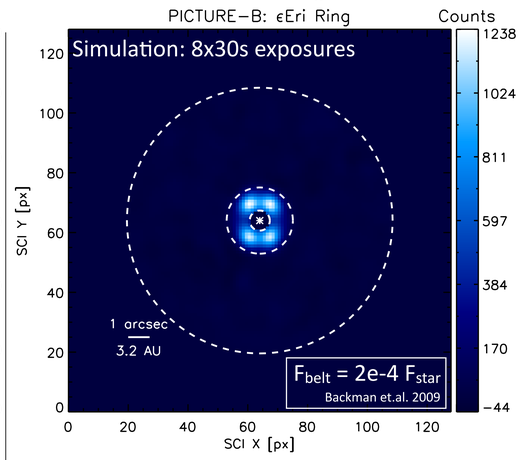
The total measured wavefront error is < 14 nm RMS, comparable to the expected DM surface (below). High spatial-frequency DM scalloping (solid arrow) primarily scatters light into "diffraction spikes" outside the science region (solid arrow).



Science Camera Contrast Map

The contrast map is generated from a dark subtracted, mean null image divided by the peak of the smoothed bright output.

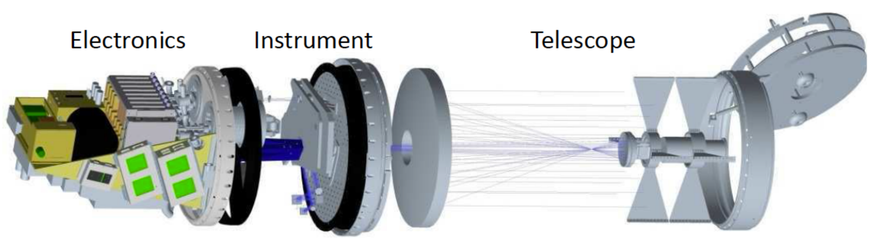
Simulated εEri warm ring observations

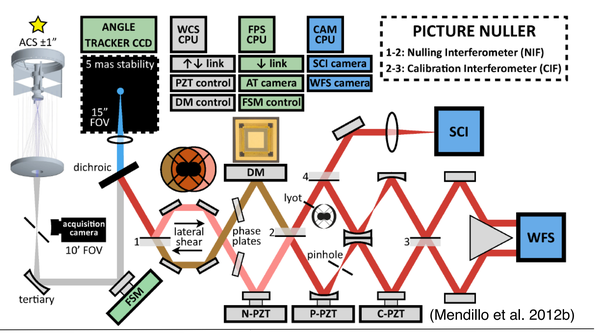


Simulated Flight Image

The predicted 3AU ring can be seen above, using the contrast measurement to the left, the ring is cut-off by (horizontally oriented) nuller transmission minima at 0" and 0.9".

The Payload

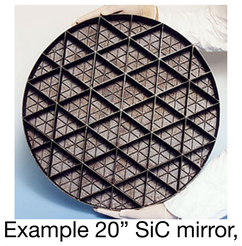




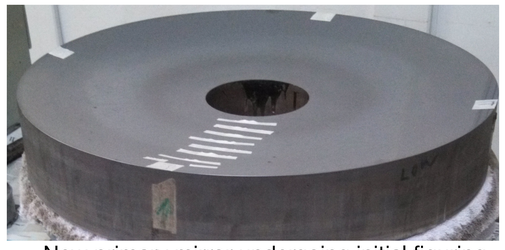
(Mendillo et al. 2012b)

New Primary Mirror

A new lightweight silicon carbide primary mirror is currently being manufactured by Northrop Grumman AOA Xinetics.



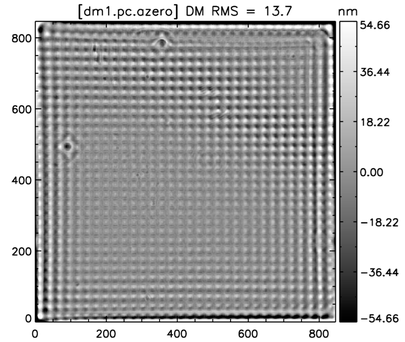
Example 20" SiC mirror, http://www.northropgrumman.com.



New primary mirror undergoing initial figuring.

New Deformable Mirror

A new MEMS deformable mirror from Boston Micromachines is being prepared for integration. The figure at right shows the expected flattened surface figure.



Acknowledgements:

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References:

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