Closed-Loop Performance of the Magellan Adaptive Optics VisAO Camera

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Visão: (Portuguese) n. eyesight; sight, view; vision; intuition

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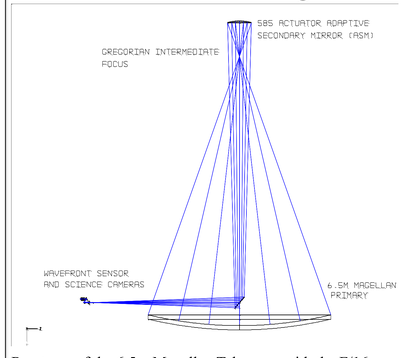
ABSTRACT

The Magellan Adaptive Secondary AO system:
• Scheduled for first light in the fall of 2012 on the Magellan Clay 6.5 m telescope
• Will simultaneously perform diffraction limited science in the mid-IR and visible
• The mid-IR imager is the CLIO 3-5 μm camera
• The VisAO instrument will offer a suit of observing modes for high resolution imaging in the visible (0.5-1.0 μm)

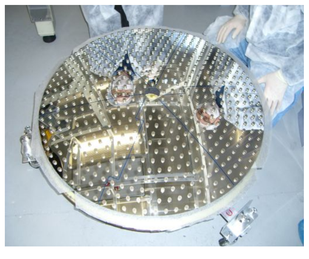
The VisAO Camera:
• Will operate as an imager, using a 1K^2 E2V CCD47 with 8.5 mas pixels
• The VisAO camera will have a full suite of filters, coronagraphic focal plane occulting spots, an SDI prism, and a separate tip/tilt AO loop.

We also present excellent results from our 1kHz closed loop test of the full AO system in the Arcetri test tower. These results include our 85% Strehl image at 982 nm. We also present our alignment scheme for the boresight reference and retroreflecting Calibration Return Optic (CRO). This micron-leve alignment presents many unique and challenging problems which we have over come with custom alingment fixtures and carefully designed optics mounts. We present hardware images of many of our recently integrated custom optical components, including the prototype Wollaston prism, the SDI filter suits, and our chrome coronographic focal plane masks.

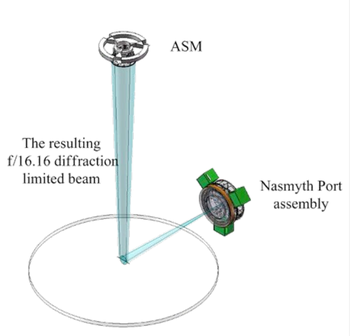
Magellan AO Overview



Ray trace of the 6.5m Magellan Telescope with the F/16 adaptive secondary. Note the Gregorian intermediate focus.



The thin shell adaptive secondary mirror



Magellan's Gregorian design has a concave F/16 adaptive secondary mirror (ASM) that can be tested off-sky with a retro-reflecting optic at the far ellipsoidal conjugate. Our 85 cm diameter ASM uses 585 actuators with <1 msec response time and will allow us to perform low emissivity AO science. We will achieve very high Strehls (~98%) in the Mid-IR (8-26 microns). We will use a high order pyramid wavefront sensor (WFS) similar to that used in the Large Binocular Telescope AO systems. Our VisAO science camera is on the same stage (the "W-unit") as the WFS and will allow us to *simultaneously* perform mid-IR and visible adaptive optics science.

ACKNOWLEDGEMENTS

This project owes a debt of gratitude to our partners and collaborators. The ASM and WFS could not have been possible without the design work of Microgate and ADS in Italy as well as Arcetri Observatory and the LBT observatory. We would like to thank the NSF MRI and TSIP programs for generous support of this project in addition to the Magellan observatory staff and the Carnegie Institute. We would also like to thank the engineers and staff at Optimax for doing an excellent job fabricating the ADC, a challenging and unique optic.

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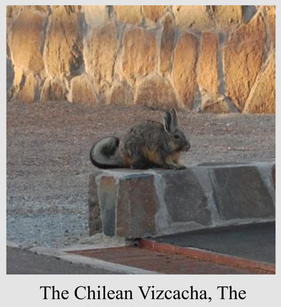
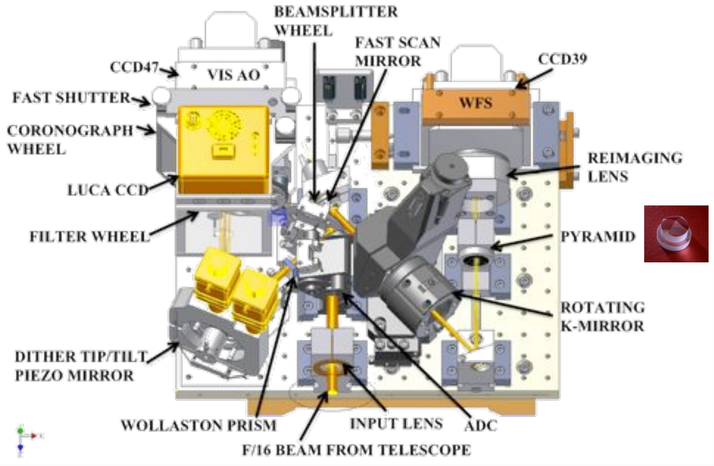
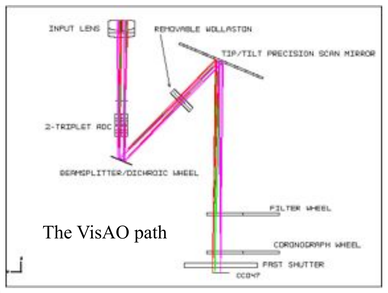


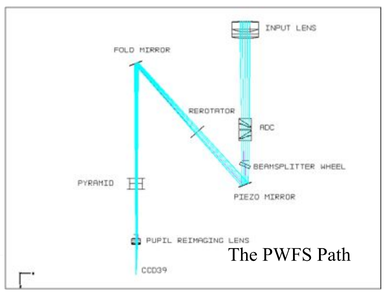
The Chilean Vizcacha, The VisAO Mascot

The W-Unit: Pyramid Wavefront Sensor and VisAO Science Camera



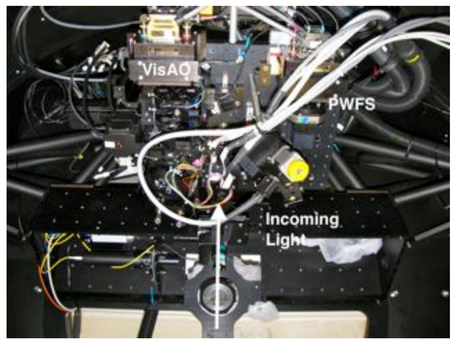


The VisAO path

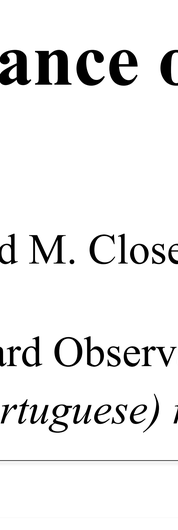


The PWFS Path

The W-Unit is an optical board on three translation stages that can patrol a 2.3' x3.2' field at the Nasmyth focal plane in order to acquire NGS guide stars and VisAO science targets. The W-Unit contains two optical channels: the pyramid wavefront sensor channel and the VisAO science channel. Incoming visible light passes through a telecentric lens and a triplet lens that converts it from a diverging F/16 beam into a converging F/49 beam. This light then passes through the ADC before hitting a beam splitter wheel that divides the light between the WFS sensor and VisAO channels.



Arcetri Closed Loop Tower Tests



The Arcetri Test Tower

Closed loop performance at 982 nm of the complete AO system in the Arcetri test tower. (a) Theoretical PSF at this F/# and wavelength. (b) AO corrected image of the fiber source with the tower vibration, ambient environment, and injected "seeing" as the sources of turbulence.

CRO Alignment Scheme

Our magenetic kinematic ball-in-groove interface plates allow us to remove and reinstall the CRO with a repeatability of better than a micron.

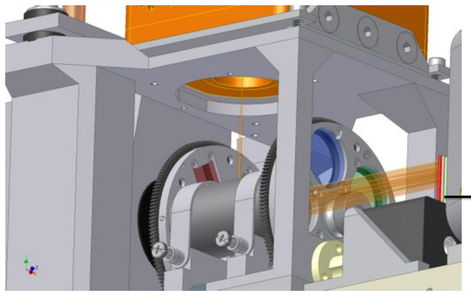
Removing and installing the CRO plate, as seen reflected in the secondary.

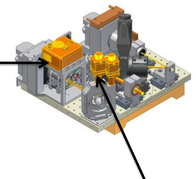
Because the Magellan telescope does not have a hexapod, our truss system and removable 5-axis stage allow us to align the CRO to the near ellipsoidal conjuate of the ASM

Our remotely controlled piezo 5-axis stage allows fine adjust on the order of a micron.

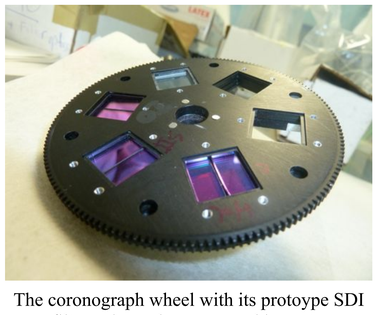
A removable handgun laser can be mounted on a delrin cap in the center of the ASM for use both to verify the CRO position and as a boresight reference.

VisAO High Resolution Imaging

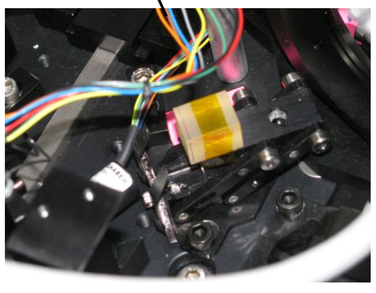




Prior to reaching the CCD47 at the VisAo focal plane, incoming light passes through a filter wheel holding a suit of Sloan filters. The light then passes through a baffle tube and then passes through the prototype coronograph wheel that contains several square optics. 3 of these optics are Spectral Differential Imaging (SDI) pairs that will be used for speckle suppression and high resolution imaging of disks and faint companions at OI, SII, and H_α. The remaining slots of the wheel can be used for coronographic spots of various designs and optical densities, depending on the science case.

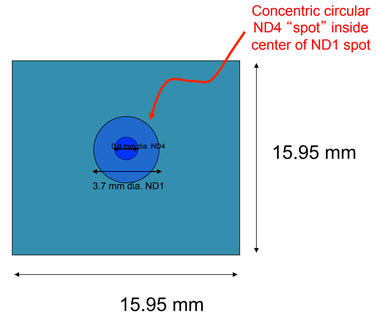


The coronograph wheel with its protoype SDI filter pairs and coronographic spots.



Our prototype quartz Wollaston prism mounted on its elevator stage that can be raised and lowered in and out of the beam. Ultimately we have adopted a calcite design. The larger birefringence of calcite allows for a much more shallow cut angle and thinner prism that minimizes astigmatism introduced into the beam.

r=0.1" ND4 and 0.1<r<1.0" ND1 Coronagraph on square window



r=0.2" ND3 Coronagraph on square window