Exploring the Formation and Evolution of Planetary Systems
Proceedings IAU Symposium No. 299, 2013
Brenda Matthews & James Graham, eds.

DOI: 00.0000/X000000000000000X

High Contrast Imaging of an Exoplanet with the Magellan VisAO Camera

Jared R. Males[1†], Laird M. Close[1], Katie M. Morzinski[1†], Derek Kopon[2], Alfio Puglisi[3], Victor Gasho[1], Kate Follette[1], Simone Esposito[3], Armando Riccardi[3], Enrico Pinna[3], Marco Xompero[3], Runa Briguglio[3], Carmelo Arcidiacono[4], Phil M. Hinz[1], Alan Uomoto[5], Tyson Hare[5], Fernando Quiros-Pacheco[3], Javier Argomedo[3], Lorenzo Busoni[3], T.J. Rodigas[1], and Ya-Lin Wu[1]

[†]NASA Sagan Fellow

[1]Steward Observatory, University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721, USA
email: jrmales@as.arizona.edu

[2]Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

[3]INAF - Osservatorio Astrofisico di Arcetri, Largo E Fermi 5, 50125 Firenze, Italy

[4]INAF - Osservatorio Astronomico di Bologna, Via Ranzani 1, 40127 Bologna, Italy

[5]Carnegie Observatories, OCIW, 813 Santa Babara St. Pasadena, CA 91101, USA

Abstract. The Magellan Adaptive Optics (MagAO) system saw first light in November 2012 at Las Campanas Observatory (LCO) on the 6.5m Clay telescope. Here we present an introduction to MagAO's visible wavelength diffraction limited imager, VisAO. VisAO delivers Strehl ratios greater than 30% from 0.62 microns (r') through 1 micron, where Strehl is even higher, and achieved resolutions as small as 20 milli-arcseconds. We took advantage of the excellent performance of MagAO/VisAO to conduct high contrast observations of an exoplanet in the optical. With VisAO, we are, for the first time, able to begin characterizing exoplanet atmospheres in the optical from the ground.

Keywords. Planets and satellites: individual (Beta Pictoris b); Stars: individual (Beta Pictoris); Stars: planetary systems; Instrumentation: adaptive optics

1. Introduction

During first light commissioning of MagAO (Close *et al.* (2012)) and its VisAO science camera (Males *et al.* (2012), Kopon *et al.* (2012)) we observed the known exoplanet host star β Pictoris (Lagrange *et al.* (2009)). MagAO consists of a 585 actuator adaptive secondary mirror and 28x28 pyramid wavefront sensor (PWFS). VisAO is a CCD camera co-mounted with the PWFS, with a specialized compliment of filters, a wollaston prism, and an occulting mask coronagraph. We obtained over 2 hours of open-shutter at 0.986μm on β Pic, using the VisAO CCD and the occulting mask to prevent bleeding.

2. Results

We show the point spread function (PSF) measured during this observation in Figure 1. MagAO/VisAO delivered a Strehl ratio of 40% to the VisAO CCD in typical seeing conditions at LCO. One can also observe the effect of the coronagraphic occulting mask in Figure 1. With such good Strehl ratios, MagAO/VisAO is capable of high contrasts. We reduced the β Pic observations with the KLIP principle component analysis (PCA) algorithm (Soummer *et al.* (2012)). The 5σ detection threshold at $0.5''$, shown in Figure 2, is $\sim 3 \times 10^{-5}$. The details of our detection of the $\sim 10 M_J$ exoplanet β Pictoris b

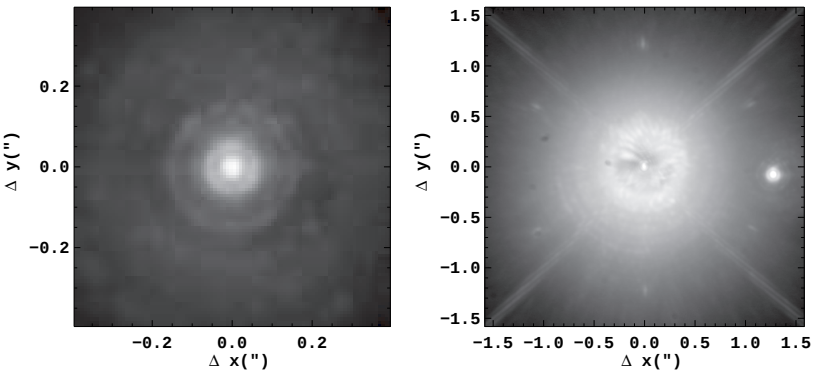

Figure 1. MagAO/VisAO 1μm PSFs. At left we show the off-coronagraph PSF, which has a Strehl ratio of 40%. At right we show a 2 hour exposure, behind the occulting mask.

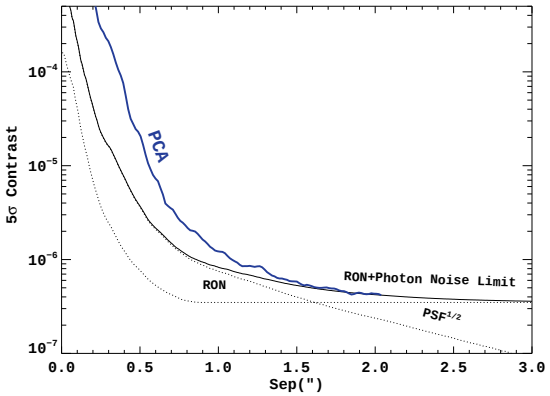

Figure 2. MagAO/VisAO 1μm 5σ Contrast Limits. In this plot we show the contribution of readout noise (RON) and PSF halo photon noise to the detection limit of this observation. The detection limit due to RON is not flat due to the occulting mask. We also show the 5σ profile achieved with principle component analysis (PCA) using the KLIP algorithm.

are provided in Males *et al.* (2013). We also observed this exoplanet with MagAO's IR camera, Clio — see Morzinski *et al.* (2013) in these proceedings.

Acknowledgements MagAO development was supported by the NSF MRI program, the TSIP program, and the Magellan partners. JRM is grateful for the generous support of the Phoenix ARCS Foundation. LMCs research was supported by NSF AAG and NASA Origins of Solar Systems grants. KMM was supported under contract with the California Institute of Technology (Caltech) funded by NASA through the Sagan Fellowship Program.

References

Close, L. M., *et al.* 2012, *SPIE*, 8447, 84470X
Males, J. R., *et al.* 2012, *SPIE*, 8447, 844742
Kopon, D., *et al.* 2012, *SPIE*, 8447, 84473D
Lagrange, A. M., *et al.* 2009, *A&A*, 491, L21
Soummer, R., *et al.* 2012, *ApJ*, 755, L28
Males, J. R., *et al.* 2013, *In Prep*
Morzinski, K. M., *et al.* 2013, *IAUS 299*