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# First light of the affordable adaptive optic system “CIAO” at Pic du Midi Observatory

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## Abstract

The Pic du Midi observatory in the French Pyrénées mountains is known for the quality of its planetary observations[4]. The results obtained have a renowned scientific value[1][3]. Imaging techniques are constantly evolving and teams at Pic du Midi are always looking for new technologies. The most recent step is the development of an adaptive optics system named CIAO. It is a compact and affordable system of adaptive optics developed in a very fruitful collaboration between Imagine Optic, Paris Observatory, and S2P (the planetary team at Pic du Midi Observatory). The device could interest many observatories equipped with telescopes between 0.5 and 2m in diameter. Introduced for the first time at EPSC 2017[2], CIAO has been tested on the sky since then, and we present the results.

## 1. Introduction

The CIAO system for "Compact Innovative.Adaptive Optics" is an adaptive optics system incorporating standard components available on the market. It incorporates a deformable mirror, and a wavefront sensor based on a microlenses array (a Shack-Hartmann). It can be put up directly on a standard telescope eyepiece holder. A control software uses the images of the wavefront sensor to control the deformable mirror. The static aberrations of the telescope can then be removed, but also the aberrations caused by the atmospheric disturbances above the telescope. The imaging camera is in a secondary imaging plane and benefits of the corrections made by the deformable mirror. The quality of acquired images therefore increases considerably.

## 2. CIAO tested on the sky

At the end of October 2017, we made our first measurement campaign at the Pic du Midi on the 1m diameter telescope open at f / 17.
The first targets observed were stars. The system was in a very classical configuration of adaptive optics because the source is punctual. Very good results were obtained among others on the star Fomalhaut (magnitude 1.17), when it was at 17 ° of elevation (see figure 1). The diffraction limit of the telescope was obtained under seeing conditions of the order of 0.7 arcsec. The loop was then working at around 400Hz. A narrow filter centred at 890nm made it possible to get rid of atmospheric refraction.
Under equivalent conditions of seeing, the Mars planet was targeted (see figure 2). The planet was only 4 arcseconds in diameter at this date. One series was acquired in a closed-loop configuration and another in open-loop configuration with the deformable mirror set to plane. Traditional and identical processing of sorts, registrations, enhancement of contrasts were applied on each of the two sets of images to compare them. The improvement of the image quality is remarkable, even better than expected. We were pretty confident in the ability of the device to compensate the optical defaults of the telescope itself, but it’s also very efficient to compensate the blurring effect due to air turbulence.

## 3. Figures

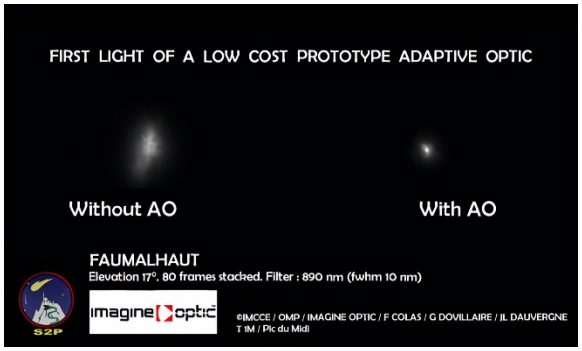


Figure 1: CIAO results on Faumalhaut observation

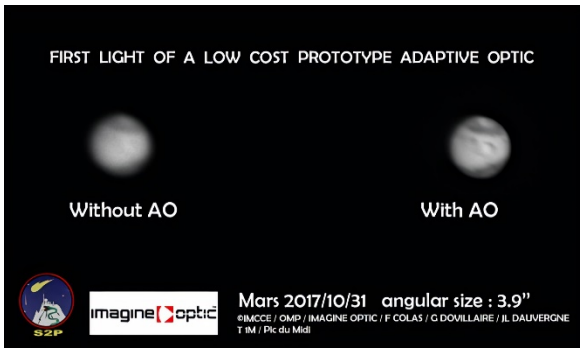


Figure 2: CIAO results on Mars observation

## 4. Summary and Conclusions

We have shown that an approach based on the use of shelf components can build a high performance adaptive optics system. The images obtained from the planet Mars show a notable gain and allow to consider a second very promising measurement campaign when the planet will be in a more favorable position.

The CIAO prototype continues to be modified and improved to ensure its smooth operation in all sky conditions, regardless of the object observed provided it is sufficiently bright, and on most telescopes. It is in planetary imaging that we expect the most spectacular results.

## Acknowledgements

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## References

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