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Space-situational awareness adaptive optics at Mount Stromlo: data analysis of the first results

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ABSTRACT

This paper presents a preliminary analysis of the first results we have obtained from the adaptive optics systems built for EOS 1.8 m telescope at Mount Stromlo. This presentation focuses on the single-camera stereo-SCIDAR for monitoring the atmospheric seeing. We briefly summarize the system, describe its on-sky performance during commissioning, compare results to numerical simulations and evaluate the remaining challenges going into the future.

Keywords: Adaptive optics, space-situational awareness, SCIDAR, satellite imaging, atmospheric turbulence

1. INTRODUCTION

Space debris in low-Earth orbit (LEO) below 1500 km is becoming an increasing threat to spacecrafts. To manage the threat, we are developing systems to improve the ground-based tracking and imaging of space debris and satellites [1-5]. The systems include a SCIDAR (SCIintillation Detection and Ranging) instrument to monitor the atmospheric turbulence for optimal performance evaluation and long-term planning [3-4], an adaptive optics assisted imager, a laser-guide star and an adaptive optics assisted tracking and pushing system.

We are currently in the commission stage of the project that has its origins in the first demonstrators built in the early 2010s. Details of the AOI and SCIDAR instruments have been published in our earlier works [3-5]. Figure 1 illustrates their opto-mechanical design and the layout at the coude-laboratory of the 1.8 m telescope of Electro Optics Systems company, based on at the Mount Stromlo Observatory.

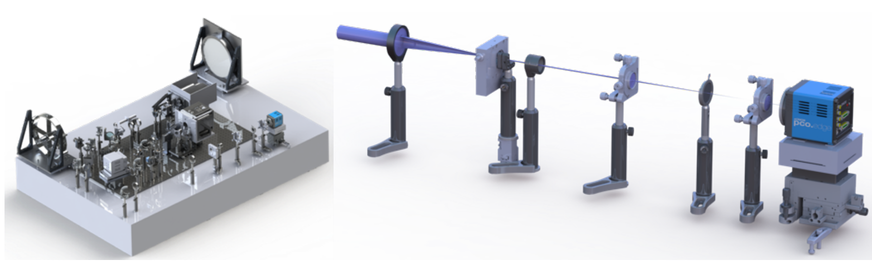

Figure 1. A three-dimensional model of the instruments. Left: illustration how AOI and SCIDAR are fitted on the optical bench. Left: a zoom on the stereo-SCIDAR.

2. RESULTS

We started commissioning SCIDAR and AOI in June 2019. The preliminary results of the former are discussed in the following, while the results of the latter were presented in [7].

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Fig. 2 illustrates some of the first results we obtained during our first commissioning tests in the August 2019. Top-left image shows an example of a time-averaged detector image, where we have re-imaged the separated pupils from a double-star (13.5” separation). Top-middle plots shows an example of detected and modelled normalized raw cross-correlation along the separation of the beams. Top-right plot shows examples of reconstructed turbulence (Cn2) profiles using two alternative data-processing methods. Bottom row shows examples of spatio-temporal cross correlations and correlation peaks representing atmospheric layers translating across the pupil due to wind.

We can see the instrument working mostly properly. Minor artefacts caused by leak through the roof prism can be fixed by masking or choosing a double star with wider separation. Unreasonably low values of Cn2 with certain configurations need to be further investigated. The preliminary results suggest that the ground layer is not dominant – significant amounts of turbulence exist up to an altitude of 2 km.

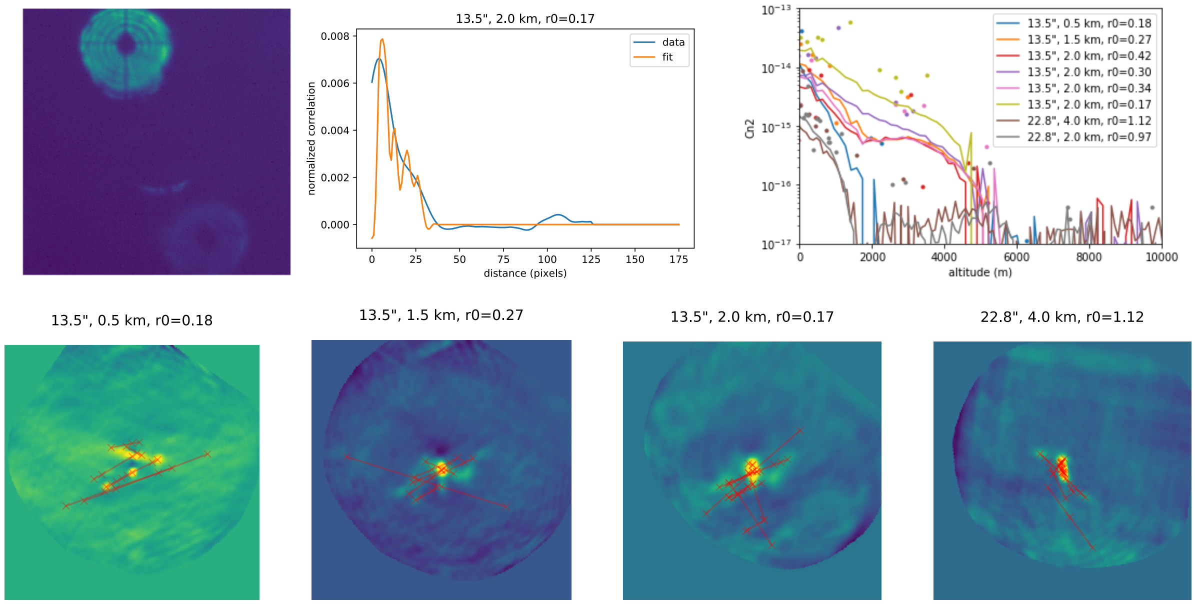

Figure 2. Illustration of Stereo-SCIDAR results obtained during a commissioning test in Aug 2019.

3. CONCLUSIONS

We are currently commissioning instruments after a multi-year adaptive optics project for space-situational awareness. Preliminary results indicate the instruments are working as intended but require further optimization. We expect further results after the commissioning is fully completed.

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