Assembly and testing of a Ground Layer Adaptive Optics (GLAO) system on ARIES telescopes

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Abstract

In this project, an Adaptive Optics technique has been implemented using a module, which was assembled using components already procured. It aims to estimate the ground layer turbulence parameters (eg: coherence time), improve image PSF and telescope data. This module makes low frequency correction suitable for slowly varying ground-layer turbulence which can be the most significant component for seeing in passive-thermally controlled observatories such as 3.6-m DOT enclosure.

Introduction

- Ground layer turbulence has been a problem for all ground-based telescopes since the advent of astronomy, but with the evolution of adaptive optics, the effects of variation in the atmosphere have been easier to correct in all kinds of telescopic data (Image, Spectroscopic, Polarimetric, etc).
- This 'seeing' caused by the atmosphere is due to random refractive index fluctuations within its turbulent layers (Figure 1-b), also called Kolmogorov turbulence

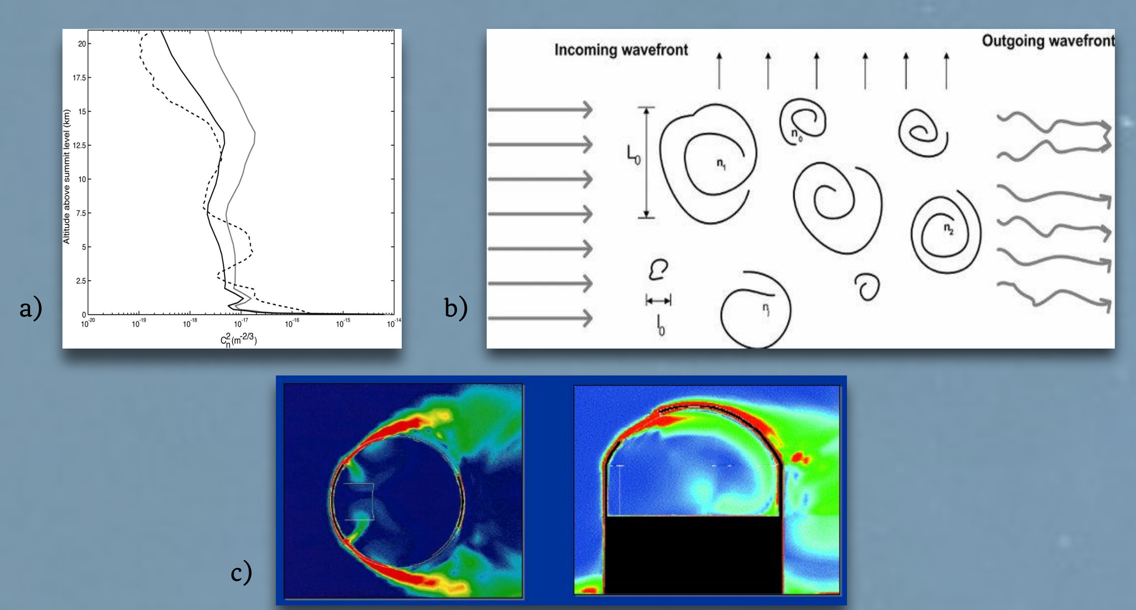
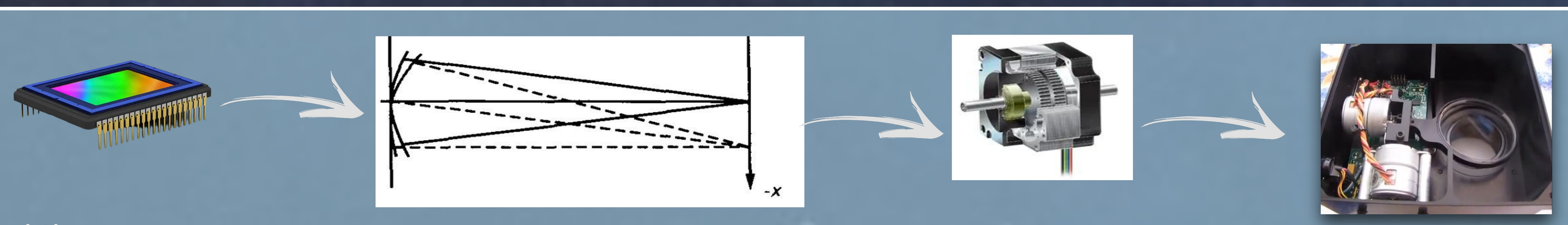
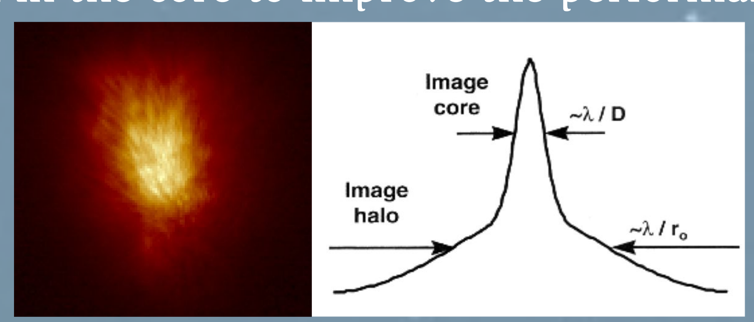


Fig 1: a) Turbulence profile over different altitudes(Source: Cherubini, T. et al.(2013)) b) Eddie lenses in a layer (Source: Trends of the Optical Wireless Communications- Chapter 11) c) Turbulent Wind around a telescope dome (Source: Computational fluid dynamics simulation (D. de Young))

Methodology



The intensity of the light is distributed between the 'core' and 'halo'. A larger fraction of intensity is in the halo for poor seeing conditions. A good AO system produces a PSF with a larger fraction in the core to improve the performance of a telescope to its diffraction limit.

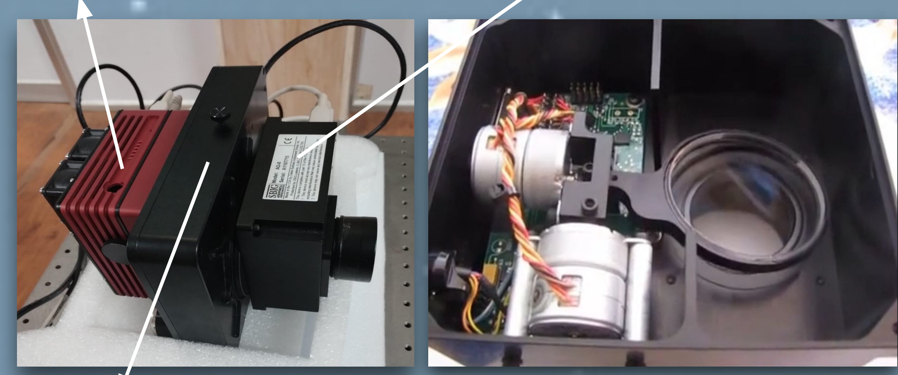


a) An image of the Polaris star on a bright night from the ST-104 telescope b) An ideal intensity profile representing the ratio of energy in core and halo.

Instrumental Setup

The ST-8300 CCD is used for imaging purposes

The AO-8 has two geared motors for X and Y directions, which tilt a 6mm thick plane parallel plate transmitting the incoming light.



The filter wheel contains 8 filter slots, a pick-off mirror, and a self-guiding CCD to focus the guide star on

Results and Future Work

- The control of beam tilt is an important and the first step in any adaptive optics system. The compensation of tilt or low-order mode alone can significantly improve an image, as shown in Figure 4, correcting for the ground layer turbulence improves a significant amount of data signal.
- This experiment aims to estimate the seeing profile variance due to the ground layer and measure its effect on the image quality.
- The next step for this project is to collect data from different types of sources in various filters with varying exposure times to get the coherence time and other parameters to get an understanding of the ground layer and improve telescope data.

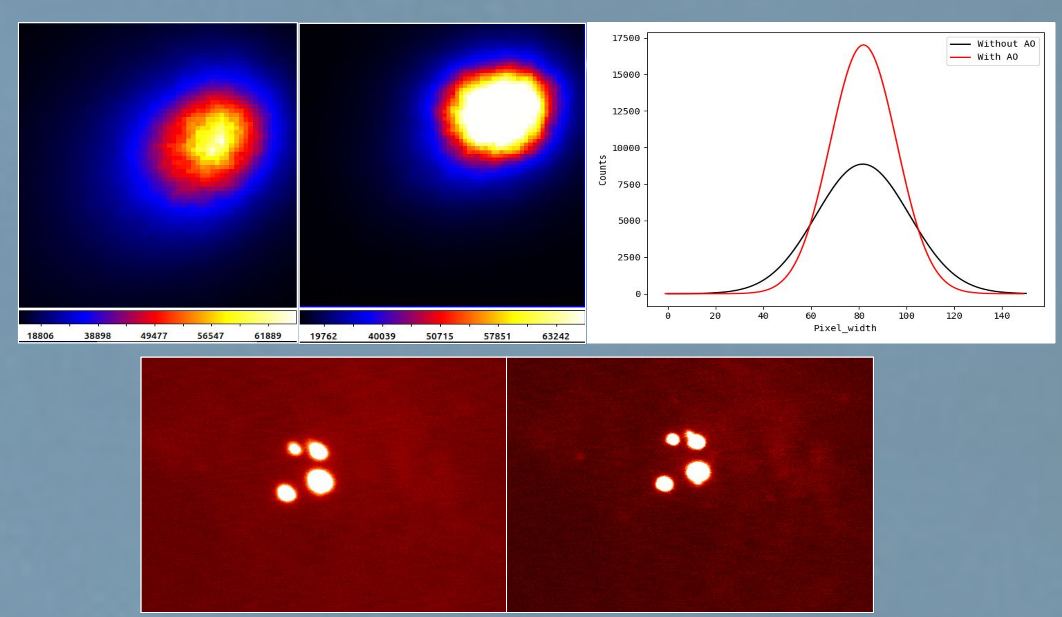


Figure 4: a) Without and With AO core to halo ratio improvement of a source b)The improvement in resolution on the trapezium cluster (HII region)without and with AO

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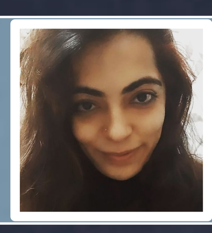

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