AO performance and optical gain tracking with a polychromatic pyramid WFS

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Abstract

The Pyramid Wavefront Sensor (PWFS) (Ragazzoni, 1996) is widely recognised as providing the best closed-loop performance for high contrast single conjugate adaptive optics (AO) systems, with many current and future AO systems selecting the PWFS as their primary natural guide star wavefront sensor. However, the challenges posed by future high contrast instruments, such as those planned for the Extremely Large Telescopes (ELTs), will require even better AO performance and more accurate wavefront measurements. Here we propose the use of a polychromatic PWFS to enhance the AO performance, using a microwave kinetic inductance detector (MKID) (Day et al., 2003) array as the PWFS detector. An MKID array is a superconducting detector that provides an arrival time and a measure of the energy of each photon incident on the array over both the visible and infrared. Sorting the photons into wavebands allows us to simultaneously measure the wavefront at multiple wavelengths. A polychromatic PWFS has the potential to significantly improve AO performance: increasing the number of photons for the wavefront measurement; combining the benefits of shorter (higher sensitivity) and longer (greater linear range) wavelengths; and enabling a method to measure the PWFS optical gains. Here we will demonstrate the advantage of using a wavelength sensitive detector, presenting a method to track the optical gains and optimise the polychromatic reconstruction methods. We demonstrate improvements in contrast and limiting magnitude using a polychromatic PWFS and relate this to the number of wavebands.

Keywords: Pyramid Wavefront sensor, MKID

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