Bi-O-edge sensors: the Foucault-knife-edge advantage in the race to sensitivity.

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Abstract

The Pyramid sensor (Ragazzoni, 1996) is the reference for Single Conjugate Adaptive Optics. We revisit the concept of dual channel 2-sided Pyramid sensor (Phillion, 2006) and generalize it into the new class of the Bi-Orthogonal Foucault knife-edge sensor (Bi-O-edge). We propose innovative opto-mechanical concepts that allow to get rid of the dynamic beam modulation. We compare the properties of the Bi-O-edge with the Pyramid using the Convolutional model (Fauvarque, 2019) and end-to-end simulations.
Thanks to the analytical tool, we show that the nature of the measurements of the Pyramid and the Bi-O-edge exhibit significant differences. In particular, we show that depending on the number of degrees of freedom, the Bi-O-edge can outperform the Pyramid in terms of sensitivity. Taking an eXtreme AO application (e.g. PCS on the ELT), we show that the Bi-O-edge sensitivity gain can exceed one stellar magnitude.
Last but not least, the spatial resolution of the Bi-O-edge can be extended by a factor of 2 thanks to a super-resolution capability (Oberti, 2022) that surpasses dramatically the one of the Pyramid.

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