Exploring the capabilities of the geometric WFS

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With the imminent arrival of large telescopes, the development of incredibly sensitive and faster Adaptive Optics (AO) systems has meant new challenges in Wavefront Sensor (WFS) performance. The investigation of new algorithms, techniques and concepts is therefore a booming field. In general, an ideal WFS would have the following main characteristics: high dynamic range, sensitivity, linearity and efficiency. To date, no WFS has been found that exhibits all these properties at the same time.

For the new era of telescopes, the Pyramidal Wavefront Sensor (PyWFS) has replaced the Shack-Hartmann (SH) WFS as the reference for high-performance AO. The characteristics that have led to its implementation are the increase in sensitivity through modulation control, improved SNR and adaptability to correct for wavelength, and a better adjustment to the source brightness thanks to the possibility of changing the spatial sampling and gain during operation and adjusting the modulation amplitude. However, the PyWFS is a nonlinear device. The most widespread way to deal with nonlinearity is to apply modulation at the cost of reducing sensitivity[1].

Consequently, there are still some points against it. The need for dynamic modulation requires the incorporation of a high-frequency moving component inside the instrument and therefore the implementation of high-precision optics. This is why the study of new strategies for sensing and reconstruction continues to be an active field of researching.

There are several studies comparing the response of SH and PyWFS [2,3] but despite the great results obtained with the geometric WFS, named as Two Pupil Plane (TP3)[4], this sensor remains unknown among the AO astronomical society. Here we want to present a complete study of the TP3 WFS to compare its capabilities versus the widespread WFS in Astronomy, the SH and the PyWFS. To carry out the comparison, a system was simulated in Python using the Hcipy library to generate the optical elements of the system. Linearity, dynamic range, sensitivity and efficiency tests have been achieved and the results are very promising.

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