Fourier-type wavefront sensing in linear and nonlinear regimes

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Abstract

Nonlinear Fourier-type wavefront sensors (WFSs) use optical Fourier filtering with a suitable optical element in the focal plane. They are included in the design of advanced adaptive optics (AO) instruments, with the 4-sided pyramid wavefront sensor (PWFS) being the most popular choice. Conventionally, these sensors perform wavefront reconstruction using linear methods like interaction matrix-based approaches. These algorithms have been shown to be robust in linear regimes. Depending on, e.g., atmospheric or system parameters, linear methods can critically degrade the instrument's performance due to the nonlinearity of the WFS models.

Here, we present the solver nonlinear pyramid extension (NOPE) which is applicable to all Fourier-type WFSs. It works by employing an iterative technique to circumvent the major drawbacks associated with linear approaches. The motivation for this work is to evaluate the performance of several Fourier-type WFSs in linear and nonlinear regimes.

The robustness of nonlinear Fourier-type wavefront sensing with the NOPE is demonstrated for ELT-scale instruments. Different realizations of Fourier-type WFSs are investigated in both linear and nonlinear regimes. Additionally, we investigate whether nonlinearity problems can be overcome by considering nonlinear reconstruction algorithms based on the full WFS model.

Keywords: nonlinear wavefront sensing, pyramid wavefront sensor, Fourier, type wavefront sensors

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