Title: Wave Front Analysis with Laser Guide Stars on ELTs

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Abstract:

Adaptive Optics (AO) allows to correct in real time the atmospheric perturbations thanks to the analysis of the turbulence with a WaveFront Sensor (WFS). In order to increase the sky coverage, highly restricted when using only natural guide stars, Laser Guide Stars (LGS) are created in the Sodium layer of the atmosphere. These three-dimensionnal extended objects induce specic problems on the measurement of wavefronts. Some of these problems become critical on the Extremely Large Telescopes (ELTs), the next generation of telescopes ranging from 25 to 40 meters in diameter. The goal of this work is to study the specicity of the wavefront analysis on LGS in the framework of the ELTs, and to optimize the WFS measurement accuracy on such objects.

To do so, we first studied the characterization of the effects of differential focal anisoplanatism on wavefront measurements. Using a diffractive propagation model, that is to say, taking into account the effects of phase and amplitude, we have calculated these effects in the case of a 40-m telescope, taking into account the stage of phase reconstruction by tomography. We have shown that these effects are actually low in amplitude at least for most applications. In parallel, we proposed an analytical model for assessing these effects relatively quickly in a random configuration. We addressed then the wavefront measurement itself. We proposed a simple model to classify the different sources of errors identified in the literature (fixed aberrations related to the sodium layer, non linear effects in the turbulent phase measurement on a LGS). Then we characterized the different error terms in the decomposition, considering the case of a SH WFS.

We studied in detail the evaluation of the non-linearity error and the sensor noise error when comparing different algorithms for estimating positions of spots. Then we evaluated the impact of the atmospherical Sodium layer variations, considering analytical Sodium profiles as well as real data. We considered also here the stage of tomographic reconstruction. Finally, we managed to deduce from this study the parameters of the WFS to be favored when optimizing the wavefront analysis on LGS, in the case of ELTs.