Resum de la Tesi: **"*New interferometric technique for piston measurement and phasing of segmented mirrors*"**

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In this Ph.D. thesis work a new interferometric technique for measuring piston error in segmented mirrors is presented. An interferometer based on this new technique has been designed and built in order to assess the feasibility of the technique.

This work has been motivated by the demand for such instruments by the astronomical community. The next generation of ground-based telescopes will use a segmented primary mirror due to the large diameter required. This successful technique to build large mirrors has already been applied in two telescopes worldwide, the Keck telescopes, and some others are already being built or are in their design stage. But the astronomical community demands new instruments in order to improve the present techniques (when Adaptive Optics based instruments come online the requisites for such techniques will have to be greatly improved). A new approach for building such systems in proposed in this thesis work.

The interferometric piston phasing error measurement system presented in this thesis work has the desirable feature of being able to carry out nanometric piston measurements locally with no interaction with the segments during daytime, saving valuable observation time for scientific purposes. Moreover, the dynamic range has been increased with respect to other phasing techniques proposed.

Starting from a classical Michelson interferometer layout, a set of modifications have been introduced in order to make it suitable for use as a piston measurement instrument. One of the beams is sent to the contact region between the two segments (or intersegment). The reference beam is sent to a region of one the segments close to the intersegment. This provides a high degree of vibration insensitivity (in five degrees of freedom) and a high positioning tolerance. The measuring principle is based on a novel optical fiber illumination technique that allows the simultaneous observation of narrowband and broadband interference patterns. Using this technique an absolute reference has been introduced in a monochromatic interference pattern, thus allowing to unambiguously remove the $\lambda/2$ indetermination. The system has been tested in the lab to a great extent and its final tests have been carried out at the test bench of the GTC telescope.

The main conclusion on the performance of the system is that it is able to measure piston error between segments with a repeatability of 5 nm rms in a range of 30 µm. Tests have also shown that the system is able to measure residual tip and tilt misalignments, although it was not specifically designed to do so. A detailed analysis on the limitations of the system has also been done and it has been found that the performance of the system is limited by the effect of atmospheric perturbations on interferograms.

But the aim of this work is to develop an instrument for measuring piston error in segmented primary mirrors of telescopes. It is proposed to mount the interferometer on a robotic arm, which could be the segment exchange arm, and to measure the piston phasing error locally at each intersegment. This has the advantages that the primary mirror can be phased during daytime while pointing at the expected observation region of the sky for that night, thus no gravitational stresses are applied as no pointing is required, and also that a segment can be

phased again less than 10 minutes after being exchanged. Other limitations related to the interferometer performance when measuring piston in a segmented primary mirror of a telescope have been identified. These include the need for the automatization of the alignment procedure and the effect of the vibration of the positioning arm on interferograms.

As future work, a proposal for a redesign of the interferometer is done in order to overcome these limitations and to compensate the effect of environmental perturbations on interferograms. Some of the work on the design and implementation of an active vibration control system is presented.

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