LabCom NANO-PtoV

Ph D Thesis

Metrology of large optical components at sub-nanometric level accuracy

Context

Measuring the surface error of very high precision optical components, at sub-nanometric level for synchrotron X-ray mirrors or optics of coronagraphic instruments for imaging exoplanets, is a real challenge.

This challenge has two essential key points: i) the possibility of measurements at ultra-high precision (a few Ångstrom rms) and at very low noise over few centimeters pupils' size, and ii) the possibility of reconstruction by digital stitching of a much larger pupil without degrading the precision of the measurements.

This PhD thesis will be carried out in the framework of a ANR Joint Laboratory research program between the Laboratoire d'Astrophysique de Marseille (LAM) and the Winlight optical company, with a close collaboration with the metrology lab of the ESRF (www.esrf.eu).

PhD Work

In recent years, several techniques have been developed for the surface metrology of large aperture optics: Long Trace Profiler (LTP), Nanometer Optical component measuring Machine (NOM), Stitching Shack Hartmann wavefront sensor (SHARPeR), Relative Angle Determinable Stitching Interferometer (RADSI), each of these suffering from several limitations such as limited spatial resolution, long measurement time, measurement angle calibration, …During the first part of the PhD thesis, based on ESRF expertise, we aim to develop a new high-accuracy optical head, to be integrated into one or more measurement benches. With its high-accuracy this new optical head should improve the digital stitching reconstruction at the nanometre level of surface figure error measurements, using Fizeau metrology, for large optics.

In the second part, a series of surface figure error measurements with ultra-high precision and very low noise (aiming for sub-nanometer level accuracy) will be achieved and combined using the digital stitching reconstruction technique. This will be done using the ultra-stable Fizeau metrology bench which is currently under construction by Winlight at the LSBB (Laboratoire Souterrain Bas Bruit), in order to exploit at most the extreme environmental stability of this underground facility.

The research program will involve optimization of the optical design (optics & detector) of the new head through to the detailed characterization of the performance in a prototype metrology bench. The student will be expected to contribute to the optical design, software integration and experimental measurements of the system performance. Finally, it is aimed to demonstrate the use of the calibrated device for high-precision mirror characterization on one or more of the metrology benches, including that at the LSBB.

Cursus and Skills

Master M2 or engineering school diplomas in Optics or Physics (optical design, metrology, interferometry, image processing, etc.)

Constraints and risks

The work will take place between Marseille and Grenoble in the 2 first years of the PhD, with travels/stays at Winlight premises in Pertuis during the third year.

University Information:

Doctoral School: ED352 Marseille – *Physique et Sciences de la Matière*
PhD Supervisor: Marc FERRARI, Laboratoire d'Astrophysique de Marseille, PI ANR NanoPtoV
Academic co-supervisor: Raymond BARRET, European Synchrotron Radiation Facility (ESRF, Grenoble)
Industrial co-supervisor: Julien MARQUE, Winlight Systems