

Name of host organization : LP3 (Lasers Plasmas et Procédés Photoniques) laboratory, Marseille
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Title: Development of X-ray phase contrast imaging with a laser plasma source

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Summary of the subject :

Recently new X-ray sources of very short pulse duration ($< 1 \text{ ps}$ (10^{-12}s)) appeared thank to the fast technological progress of advanced ultra-short and high power laser sources. The emergence of these new sources opens new horizons for ultrafast science and x-ray science. The current and potential applications are numerous and varied (solid state physics and surface, plasma physics, biology, health, etc.). These "hard" plasma laser X-ray sources ($> 4 \text{ keV}$) are generated by the interaction of an intense laser pulse ($I_{\text{las}} > 10^{16} \text{ W/cm}^2$) with a solid [1]. First proof of concept of X-ray phase contrast imaging have been already performed at LP3 laboratory with X-ray photons of 17.48keV [2]. In addition, new advancement, based on Multilateral Shearing Interferometry (only one interferometric grid is used), have been carry out in order to extracte quantitative informations of sample from X-ray images (as refractive index, thickness of the sample).

The main objective of this Apprenticeship is to improve the experimental set up of X-ray interferometry in terms of :

- ✓ Knowledge of the itself X-ray spot shape (X-ray metrology). The aim is to have access to relative modification of X-ray wavefront itself in function of laser conditions used to produce X-ray radiation. This part will be supported by simulations and/or experimental measurements.
- ✓ Acquisition of images on composite materials: Due to their high strength-to-weight ratios, composite materials are widely used in the aeronautic industry and, to a lesser extent, in the automotive and aerospace industries. During internship, Master student will acquire of X-ray phase contrast images. Efforts will be done to achieve a better spatial resolution. For that, the experimental set up and acquisition procedure should be improved.

Subject is in collaboration with CEA List (Paris Saclay University) and compatible with covid pandemy/possibility to do only simulations and /or experimental part depending of the student's profile. Research or engineer profile are suitable.

Additional information :

* Keywords : X ray source, X-ray imaging and phase contrast imaging, laser-matter interaction, laser, ultrafast phenomena

* Required skills : wave optic

* Begin/End dates (min 7 weeks for Internship): 2022

* Miscellaneous : possibility of extension with 6 months of paid internship and further thesis.

Thesis subject will carry on the following research field: generation and applications of hard X-ray radiation source.

[1] Y. Azamoum, R. Clady, A. Ferré, M. Gambari, O. Utéza, and M. Sentis, "High photon flux $K\alpha$ Mo x-ray source driven by a multi-terawatt femtosecond laser at 100 Hz," *Opt. Lett.* **43**, 3574-3577 (2018)

[2] Gambari, M., Clady, R., Stolidi, A. *et al.* "Exploring phase contrast imaging with a laser-based $K\alpha$ x-ray source up to relativistic laser intensity". *Sci Rep* **10**, 6766 (2020).