

Year 2022 – 2023

Internship (Master 2)

**Name of host organization : LP3 (Lasers Plasmas et Procédés Photoniques) laboratory, Marseille**

Mail address : <http://lp3.fr/>

**Title: X-ray phase contrast imaging with a laser plasma source**

**Name of the supervisor: Ferré Amélie /Adrien Stolidi**

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### Summary of the subject :

Recently new X-ray sources of very short pulse duration ( $< 1 \text{ ps}$  ( $10^{-12}\text{s}$ )) 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  $17.48\text{keV}$  [2]. In addition, new advancement, based on Multilateral Shearing Interferometry (only one interferometric grid is used), have been carry out in order to extract quantitative informations of sample from X-ray images (as refractive index, thickness of the sample). The main objective of this Apprenticeship is to improve knowledges on using feasibilities of this new x-ray source for phase contrast imaging. For that, the student will work on:

- ✓ 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). 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): 2023
- \* 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).

