POST-DOCTORAL PROPOSAL

Characterisation of fast transient phenomena using X-ray phase contrast imaging

Reference : **PDOC-DPHY-2025-000**

Beginning: March 2025 at the latest	**Deadline for application: December 2024**

Duration: 24 months – Gross salary: ~38 k€ / year (health insurance included)

Employer : CEA

Key words: X-rays, Imaging, Detector, Scintillator, transient phenomena, experimental physics.

Profile and skills required: Ph.D in experimental physics. Knowledge of instrumentation, time-resolved studies, optics, use of simulation tools and "programming for physicists". Knowledge of X-ray imaging and Monte-Carlo methods (geant4) would be a plus.

Presentation of the post-doctoral project, context and objectives:

This post-doctorate aims to develop a measurement chain dedicated to the observation and characterization of fast transient phenomena using X-ray phase-contrast Imaging (XPCI). The challenge is to provide a measurement system that can be deployed in the laboratory on a wide range of experiments that cannot be moved to the synchrotron. The performance targets are justified by issues raised by ONERA and CEA in connection with additive manufacturing, shock wave propagation in low-density polymers, and the diagnosis of carbon composite materials impacted by an electric arc.

For objects with low absorption, such as low-density polymers, liquids or plasmas, conventional X-ray imaging, which provides contrast due to variations in absorption cross-sections, proves insufficient. To complement absorption, it is possible to exploit the phase of X-rays, which enables better detection of inhomogeneities and interfaces between materials. The method chosen here to measure phase is the multilateral shearing interferometry (MLSI). It uses a unique two-dimensional checkerboard phase grating that generates a reference interference pattern on the detector. Introducing an object between the grating and the detector modifies the interference pattern, which is then analyzed by Fourier transform to reconstruct the phase. Requiring only a single phase grating, and presenting minimal X-ray flux loss, this method has favorable intrinsic characteristics in terms of sensitivity, robustness, ease of alignment and versatility, for application to dynamic imaging.

The candidate will first try to dimension the imaging system. He/she will have to set up a static methodology to prepare and optimize imaging under dynamic conditions, with the aim of achieving an imaging rate of > 1 kHz, an exposure time of the order of µs and a spatial resolution range of between 30 and 300 µm. He/she will seek to find the best method for detecting X-ray radiation at the desired rates: indirect detection using a scintillator that converts X-ray photons into visible photons, followed by detection using a high-speed camera, or direct detection using a matrix of pixelated semiconductors hybridized to an electronic chain. To achieve these objectives, he/she will use the CEA imaging bench and simulation codes developed at the CEA (CIVA software). He/she will then demonstrate the dynamic imaging of fast transient phenomena on technologically advanced X-ray sources (secondary laser emission source and liquid anode X-ray tube). Secondly, he/she will study the feasibility of extending the imaging system to very high frame rates (>100 kHz) and/or single-shot "nanosecond flashes".

Possible collaborations

ONERA – CEA – LP3 – Excillum

Welcome Laboratory at ONERA

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Welcome Laboratory at CEA List

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