

Title: Enhancement of X-ray source based on LPA for Multimodal X-ray Imaging

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Abstract

Recent advances in laser-driven accelerators have enabled the development of compact X-ray sources with unique properties, including micron-scale source size and femtosecond pulse duration. These sources, such as betatron radiation from laser–plasma accelerators, provide a powerful alternative to large-scale facilities like synchrotrons and X-ray free-electron lasers, while significantly reducing system size and cost. A key emerging direction is multimodal X-ray imaging, where complementary contrast channels—such as absorption, phase (refraction), and dark-field (scattering)—are simultaneously retrieved. This approach enables enhanced sensitivity to structural, compositional, and morphological features that are inaccessible with conventional attenuation-based imaging alone.

This PhD project will focus on the enhancement of the X-ray source capability (flux, energy, stability) required for multimodal imaging. We will develop the X-ray source as an active probe of the laser generated High-energy density (HED) plasma. It will build upon a recent demonstration of single-shot multimodal imaging using compact laser-driven X-ray sources, where techniques such as In-line Phase contrast imaging [1], edge-illumination beam tracking (EI-BT) allow simultaneous recovery of multiple contrast mechanisms in a single acquisition, even with partially coherent laboratory-scale sources. The combination of ultrafast (femtosecond) X-ray pulses and multimodal imaging opens new opportunities for studying dynamic processes, including transient states in materials, biological samples, and laser-driven experiments. This PhD project aims to go beyond the proof of principle of ref 2, by developing robust hardware and software solutions to bring together the analytical power of EI-BT with the time resolution of fifth generation light sources. Doing so the research will bridge the gap between synchrotron-level imaging and laboratory systems and it enables time-resolved studies of ultrafast phenomena and advances applications in high-energy-density physics, materials science, and biomedical imaging.

References: [1] M.Endrizzi, X-ray phase-contrast imaging, NIMA 878 (2018)

[2] Doherty, A., Fourmaux, S., Astolfo, A. et al. Femtosecond multimodal imaging with a laser-driven X-ray source. Commun Phys 6, 288 (2023)