Laser driven ultrafast X-ray sources at ELI Beamlines

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Pulsed X-ray sources driven by fs lasers provide compact alternatives to new generation large-scale X-ray facilities such as X-ray free electron lasers and synchrotrons as access to these facilities is very limited. These femtosecond X-ray sources allow probing the sample dynamics on an atomic timescale appropriate for observing atomic motions. We report the progress on the development of laser-based secondary X-ray sources at ELI beamlines.

One of the main objectives of the ELI facility [1], is to provide beams of ultrashort particles and photons sources to the user community from various fields of research. We will present progress on laser-based X-ray sources at the ELI beamlines facility which is one of the pillars of the ELI (Extreme Light Infrastructure) project. X-ray pulse sources driven by high peak power kHz femtosecond lasers such as high-order harmonic source and plasma X-ray sources have been commissioned and already entered the operation phase.

Two hard X-ray sources based on laser-plasma accelerator are being commissioned at the ELI beamlines facility. The first standalone source of betatron X-ray is the Gammatron beamline [2] located in Experimental Hall E2. It provides X-ray pulses of energies up to a few hundreds of keV in the betatron scheme and up to a MeV in the Inverse Compton scheme. The inherent synchronization with the driving laser beam makes the betatron X-ray source at the Gammatron beamline makes it a very unique platform for various time-resolved pump-probe experiments. A novel multi-lane and broadband X-ray mirror have been designed to serve as a focusing optics of these hard X-ray source for the user application [3]. The broadband Gammatron source can be used for various applications, ranging from phase-contrast imaging [4] to high-resolution X-ray imaging and tomography, time-resolved X-ray spectroscopy and diffraction, as well as for various industrial applications.

The second LPA-based hard X-ray Betatron X-ray is being developed in the ELI plasma physics platform (P3) located at the experimental hall E3 [5]. The major area of research in the P3 area includes laboratory astrophysics [6], intense laser-matter interaction, high-energy-density physics, and advanced plasma physics experiments in combination with multiple laser beams [7]. The inclusion of the hard X-ray broadband betatron source adds to the diagnostics capability of the P3 platform. This broadband, hard X-ray source aims to serve as a backlighter for various advanced laser-matter interaction experiments.

Besides, we will report a novel scheme for enhancing the X-ray flux based on betatron oscillations enhanced from nonlinear resonances due to interaction with a two-color laser field [8]. In addition, we will also introduce a new optical probing technique based on multiple passes of the probe beam through the object and relay-imaging allowing us to get a high sensitivity for the characterization of a low-density gas target for laser-plasma accelerator [9-10].

References

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