Title: Investigation and application of soft X-ray emission from targets containing micron-sized liquid droplets irradiated with intense laser pulses

Summary

Synchrotrons are commonly regarded as the best sources of electromagnetic radiation in the soft X-ray spectral region, the parameters of which exceed the parameters of traditional sources of this radiation by orders of magnitude. For this reason, synchrotrons are widely used in research in many areas of modern science and technology. However, very large investment costs of these facilities limit access to various soft X-ray methods and techniques which are available at synchrotrons.

Soft X-rays can be efficiently produced as a result of irradiation of targets with intense laser pulses. Applications of laser-driven soft X-ray sources in various fields, including solid state physics, chemistry, biology, material science were demonstrated. Laser-driven soft X-ray sources, as relatively cheap and compact, can be highly attractive for university laboratories and industrial applications. Moreover, laser-driven sources allow to study processes with very high time resolution, approaching the attosecond range, which is not possible using synchrotrons.

However, some X-ray methods and techniques require specific radiation parameters regarding spectral distribution and intensity, which makes it necessary to conduct research aimed at improving the parameters of currently used laser-driven sources. Improving these parameters by using a new type of laser targets containing micron-sized droplets is the main goal of the project.

The new targets in the form of a high-density jet containing micron-sized droplets will be formed using new devices developed under the project. Targets in the form of a xenon jet containing micron-sized droplets of liquid xenon will be produced as a result of expansion of xenon and helium gases from a high-pressure electromagnetic valve system equipped with a double-nozzle setup and cooled to -30° using a Peltier cooler coupled to the valve system. The nozzle design allows to form an elongated high-density xenon jet confined by an annular stream of helium. The high density and low temperature of xenon in the jet cause condensation and the formation of micron-sized liquid xenon droplets. Targets containing micron-sized droplets composed of non-xenon elements will be formed by ejecting a mist produced by means of a piezo-atomizer using an electromagnetic pulsed gas valve. Devices for the production of new targets will be developed and tested under the project.

Investigations on the soft X-ray emission produced as a result of irradiation of new targets irradiated with intense nanosecond and high-intensity femtosecond laser pulses will be performed. Soft X-ray spectra will be measured using spectrometers equipped with transmission or reflection gratings, and spectrometers with a crystal used as a diffractive element. The spectra will be registered with CCD cameras sensitive to the soft X-ray range. Soft X-ray yields will be measured with the use of calibrated X-ray detectors. The experimental studies will be supported by numerical simulations conducted with the use of hydrodynamic and atomic computer codes. So far, no research has been carried out on the emission of soft X-rays produced with this type of target.

Laser-driven sources based on new targets will be finally applied in the experiments on X-ray absorption fine structure (XAFS) spectroscopy and X-ray coherence tomography (XCT). A significant improvement in the parameters of the laser-driven soft X-ray sources based on the new targets containing micron-size droplets and the performances of the XAFS and XCT systems are expected.