Femtosecond time-resolved X-ray spectroscopy with a laser plasma source

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A laser plasma source of keV photons has been designed and constructed to deliver a photon flux suitable for pump-probe experiments in the spectroscopic experiments. The source was pumped by a high-repetition rate Ti:sapphire laser system of average power about 5 W. The pulse energy was sufficient to be split and to deliver jitter-free combination of the pump and probe pulses. Both pulses of 40 fs in length could be delayed to each other in a high-precision optical delay line with a resolution better than 1 fs. The pump pulse with an intensity of $\sim 10^{17}$ W/cm^2 was converted in a thin copper foil into a flux of energetic photons (8 keV, 5×10^{10} ph/s) emitted into full space (4π sr). The source was equipped in a high-resolution X-ray spectrometer with an HAPG crystal (resolving power of 2000:1) and a CCD camera with a depletion layer sensor. The measured source size was ~13 μm and a pulse duration below 200 fs was estimated in a cross-correlation procedure. Verification of the source suitability to the pump-probe experiments was based on measurement of the fast transient absorption (*K*-absorption edge) of the transition metals, specifically nickel. It was shown that the excitation wavelength influences strongly movement of the K-absorption edge and using the second harmonic as the pump changes the shift direction. This allows for extraction of some information regarding the influence of excitation on the atomic structure of nickel. The system worked with NIR/UV used as the pump and the ultrafast X-ray burst was used as the probe. Generally, the conducted experiments allow for claim that this type of the sources suiting the size of a typical university laboratory could readily become the sort of a complementary source to the large scale facilities.