The study of ultrafast phenomena using X-ray spectroscopy and related techniques at the ELI Beamlines facility

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We introduce the activities of the research programme for Applications in Molecular, Bio-medical and Material (MBM) science at the ELI Beamlines (ELI BL) facility in the Czech Republic. The MBM research programme develops methods for time resolved studies (spectroscopy, diffraction and imaging) of ultrafast phenomena in physics, chemistry and biology utilizing pulsed lasers and laser driven X-ray sources.

The ELI BL facility is part of a European Strategy Forum for Research Infrastructures (ESFRI) plan to build a new generation of research facilities in new EU member states and offer these to an international user community. The scientific activities at ELI BL will be based on the utilization of four unique short pulse lasers. Each one with a unique combination of pulse profile, repetition rate and intensity. Part of the ELI BL mission is to develop a new generation of laser driven light sources for ultrashort pulses covering the VUV to gamma-ray energy range based on plasma effects in gases and solids as well as relativistic electron acceleration. All sources have the potential to be used in combination with beams split off from their corresponding drive lasers for pump-probe experiments. In contrast to the situation at accelerator base light sources, like synchrotrons and FELs, the fact that the pump pulse can be split off from the same laser pulse that generates the X-ray pulse provides an intrinsic synchronization between the pump and the probe pulses.

Here we focus mainly on the scientific applications of the Higher Harmonics Generation (HHG) source and Plasma X-ray Source (PXS) driven by a high power kHz laser for which the MBM research programme develops experimental stations for AMO science and Coherent Diffractive Imaging, time resolved spectroscopic ellispometry as well as time resolved X-ray diffraction, spectroscopy and pulse radiolysis. These X-ray stations are complemented by a very advanced experimental environment for time resolved optical spectroscopy (including transient optical absorption, fs Stimulated Raman Scattering, 1 and 2D IR spectroscopy and spectroscopic ellipsometry).

In terms of scientific results special attention will be given to two recent publications: *Transferring the entatic-state principle to copper photochemistry, Nature Chemistry volume 10, pages 355–362 (2018), B. Dicke, A. Hoffmann, J. Stanek, et al.* and *Structural dynamics upon photoexcitation-induced charge transfer in a dicopper(I)–disulfide complex, Phys. Chem. Chem. Phys., 20, 6274-6286 (2018), M. Naumova, D. Khakhulin, M. Rebarz, et al.*

The complementary X-ray and optical data on which the articles above are based were taken at several synchrotron light sources and optical labs over a period of several years. In addition to the state-of-the-art laser driven light sources themselves, ELI Beamlines will offer a complementary set of X-ray, VUV and advanced optical techniques in one easily accessible location. In combination with advanced sample preparations laboratories (in particular for bio-samples), this will open up new possibilities for or the study of complex ultrafast phenomena in physics, chemistry and biology.