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Development of sub-ns and sub-ps time resolution capabilities on the diffraction beamline CRISTAL at the SOLEIL synchrotron

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The SOLEIL synchrotron is currently putting a great effort in developing pump-probe experiments that combine the use of ultrashort laser pulses and the pulsed X-ray beam produced in its storage ring. In such experiments, the time resolution is in practice limited by the X-ray pulse temporal width, which is of typically 80 ps FWHM in SOLEIL's standard operation mode. In view of studying ultrafast photoinduced dynamics in matter, a "low-α" operation mode [1] was tested, which can provide X-ray pulses as short as 1 ps FWHM. An ultimate temporal resolution of ~ 100 fs is foreseen by 2014 at SOLEIL, in the framework of the "femto-slicing" project [2].

The undulator-based diffraction beamline CRISTAL will use these advanced time structures in the pump-probe scheme. The sample is excited by 800 nm, 25 fs FWHM laser pulses provided by a regenerative Ti:Sa amplifier (max. output power 6 mJ @ 1 kHz). The subsequent changes in the sample's atomic structure are studied in the time domain Δt, by measuring its diffraction out of a monochromatic incident beam. The X-ray flux available at sample, which depends on the aimed time resolution, is of 6.10^8 ph/s for 7 keV, 70 ps FWHM X-ray pulses at the repetition rate 1 kHz, and 10^5 ph/s for 7 keV, 2 ps FWHM X-ray pulses at the repetition rate 10 kHz. In adequacy with modern crystallographic methods, a 2D detector is used to collect the scattered intensities, which gives access to a large portion of reciprocal space for each single measurement. Concerning time-resolved studies, the hybrid pixel detector XPAD3.2 (7.28×12.48 cm^2) available on the CRISTAL beamline has a particular advantage: it can be triggered to select only the scattering events delayed by Δt, *at any frequency* [3]. The time-resolved capabilities were developed on both the 4- and 6-circle diffractometers of the CRISTAL beamline, which ensures a great flexibility in terms of sample orientation and sample environment.

These equipments, which will be made available to users from year 2012, are intended to support studies on photoinduced structural changes in condensed matter. Our in-house research will focus on photoinduced dynamics in compounds that exhibit metal-insulator transitions or spin cross-over. The 100 fs X-ray pulses that will be provided by the "femto-slicing" source should allow experimentalists studying the structural changes on the timescales of atomic vibrations, and eventually preparing more demanding measurements on X-ray free electron lasers.

References

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