LABORATOIRE INTERACTIONS, DYNAMIQUE ET LASERS

LIDyL- LFP URA 2453

SEMINAIRE LIDyL-LFP

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Le Vendredi 27 Mars à 11H00

Bâtiment 522 - Salle 138

« Atomic photoionization dynamics at short-wavelength free-electron lasers »

The unprecedented characteristics of new XUV and X-ray Free Electron Lasers, such as FLASH, FERMI and LCLS, have stimulated numerous investigations focusing on the detailed understanding of fundamental photon-matter interactions in atoms and molecules. In particular, the effect of high intensities (up to 10^{16} W/cm^2) giving rise to multiple ionization processes as well as the temporal evolution of ultra-fast photo-induced processes (down to a few 10^{-15} s) can be studied for the first time in the short wavelength regime, i.e. at photon energies high enough to excite and to interact with strongly bound core electrons.

In recent experiments, the high intensites of the XUX-FEL pulses were used to study multiple ionization of Ar and Xe atoms as well as to explore multi-photon processes such as sequential ionization and above-threshold ionization (ATI). These experiments serve as case studies for the non-linear response of matter to short wavelength radiation and, in particular, allow for a critical comparison with theoretical predictions for this type of processes. For atomic Ar ionized at 105 eV photon energy, the study reveals e.g. the importance of strong electron correlations, in particular the decisive role of shake-up and shake-off processes for the interpretation of the observed high charge states, i.e. up to Ar^{7+} [1]. In case of atomic Xe, the combination of experimental and theoretical results on the two-photon ATI [2] reveals previously hidden substructures underlying the broad 4d giant resonance, which is widely studied in the linear regime upon one-photon excitation and represents a prototype system for strong electron correlations.

For time-resolved two-color experiments, the combination with an intense, synchronized optical laser is enabling studies of photoionization dynamics in the presence of strong optical fields, such as the modification of the angle-resolved photoelectron and Auger spectra, which reveal strong intensity modulations induced by sub-cycle interferences. The use of circularly polarized FEL light, recently available at FERMI, provides insight into dichroic phenomena. In a first application, we have demonstrated how dichroism is induced and afterwards probed in an intially unpolarized He target. The measurement of circular dichroism enables in addition the characterization of the polarization properties of XUV FEL beams in an elegant, non-invasive and straightforward fashion [3].

After these illustrating examples, future opportunities opened up with the start of operation of the European XFEL at the end of 2015 will be presented. Special focus will be given to one of the six permanent experimental stations, the SQS (Small Quantum System) Scientific Instrument, which is dedicated to the investigation of atoms, ions, molecules and clusters in intense fields and to the study of non-linear phenomena [4].

[1] M. Ilchen et al., Phys. Rev. Lett. (2014), submitted

[2] T. Mazza et al., Nat. Commun. (2015), accepted

[3] T. Mazza et al., Nat. Commun. 5, 4648 (2014)

[4] http://www.xfel.eu/documents/technical_documents