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Multi-messenger femtosecond soft X-ray spectroscopy on solids at the European XFEL

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X-ray Free electron lasers (XFELs) produce intense coherent femtosecond pulses in a large energy range, extending the capabilities of laser-based sources. The soft X-ray regime is of paramount importance since it allows resonant studies of many materials with prospective technological applications. Photon-in/photon-out techniques at XFELs have been successfully implemented to study ultrafast dynamical processes in solids. In some cases, the entanglement between the relevant degrees of freedom in the material has been understood in a single experiment. Generalizing these observations to any class of material requires the use of a multi-messenger techniques like photoelectron spectroscopy. The technique has been essential to understand the properties of complex materials, surfaces and interfaces. It provides simultaneous understanding of the electronic, spin, chemical and structural properties. The measured spectra generally contain information on the excitation spectrum and the excitation probabilities thanks to the many-body nature of the photoemission process. Furthermore, the intrinsic time scale of the photoelectric effect enables the study of the fundamental material dynamics. The technique has been successfully implemented down to the pico-second time resolution at synchrotrons. Femtosecond experiments are routinely done using high harmonic generation up to around 100 eV. The extension of the technique to higher photon energies is only possible using superconducting acceleration technology that produces femtosecond pulses at MHz repetition rates. In this contribution, some examples of femtosecond soft X-ray spectroscopy on solids at the European XFEL will be presented. Moreover, the implementation of time resolved experiments at the SXP instrument will be described.

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