

A novel beamline for advanced photoelectron spectroscopy with narrowband extreme ultraviolet high harmonics at variable high repetition rate

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Spectroscopy in the femtosecond time domain can both reveal fundamental insight in the properties of materials and provide relevant experimental tests for functional systems. The quest for sources of ultrashort photon pulses (~100 fs) in the Extreme Ultraviolet (EUV) region operating with an adjustable repetition rate up to the MHz range has led, in this last years, to the development of high harmonic generation (HHG) coherent sources based on table-top lasers. In particular, a comprehensive characterization of the photoelectron final state in ordered solids requires measurement, with a subpicosecond time resolution, of energy, momentum and spin-polarization of the photo-emitted current, with an energy and a momentum resolution comparable to those achieved using advanced synchrotron radiation sources.

We have built and characterized a versatile twin-beamline for advanced photoemission experiments based on a table-top laser HHG source operating in the EUV range beyond 200 kHz repetition rate. The beamline is able to provide 1012 photons/sec in the range 15-35 eV, and 109 photons/sec up to 75 eV, with variable repetition rate, allowing one to measure shallow core level photoemission spectra in combination with valence band ones.

Experiments on metal and topological insulator have been performed to test the capabilities of the beamline, showing a pulse duration shorter than 100 fs and an energy resolution lower than 35 meV. The possibility to choose the optimal repetition rate for a given experiment (up to at least 200 kHz, or lower) makes it possible to explore a wide excitation-fluence range in pump-probe experiments, minimizing sample heating when relevant.

The twin-branch beamline operates as a users facility. It represents a unique instrument for dynamical “all resolved photoemission experiments” to study excited states and transient electronic and magnetic configurations at surfaces, nanostructures and solids, with the possibility of covering the full Brillouin zone of complex materials.

Summary

Topic

1. Electrons and spins

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