Progress in Photoelectron Momentum Microscopy with Time-of-Flight Recording

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Abstract. Momentum microscopy (MM) is a novel way of performing ARPES. Combined with time-of-flight (ToF) recording, its high parallelization is advantageous especially for photon-hungry experiments like X-ray ARPES, spin-resolved and time-resolved ARPES. After introducing the technique, its performance is illustrated by selected examples obtained using VUV, soft-X-ray and hard X-ray photons. Full-field imaging of the transversal momentum distribution and time-of-flight detection enable recording of $I(E_B,k_x,k_y)$ arrays comprising several 105 data voxels. A key application is rapid tomographic mapping of $I(E_B,\boldsymbol{k})$ 4D energy-momentum space patterns[1]. An improved electron optics enables energies up to >7keV and large k-fields-of-view comprising tens of Brillouin zones. This large visible k-horizon enables capturing XPD patterns[2] yielding structural information. For capped films of the collinear antiferromagnet Mn2Au, the Néel vector has been aligned ex-situ with 60 Tesla pulses, prior to the MM experiment at PETRA-III. Imaging spin filters implemented in the electron-optical column open the path to *spin-resolved ARPES* with soft and hard X-rays[3], as exemplified by proving the half-metallic ferromagnetic nature of magnetite in the bulk. First fs time-resolved momentum mapping has been successful using soft X-rays at the free-electron laser FLASH (DESY, Hamburg)[4]. This instrument merges three photoemission spectroscopy techniques into a single setup, namely *time-resolved momentum microscopy* (trMM), *core-level spectroscopy* (trXPS), and *X-ray photoelectron diffraction* (trXPD).

1. K. Medjanik *et al.*, Nature Mat. **16**, 615 (2017).
2. O. Fedchenko *et al.*, New J. Phys. **21**, 113031 (2019) and ibid. **22**, 103002 (2020).
3. G. Schönhense and H. J. Elmers, J. Vac. Sci. Technol. A **40**, 020802 (2022).
4. F. Pressacco *et al.*, Nature Commun. **12**, 5088 (2021).