Absolute photoemission time delays from elemental surfaces and adsorbates

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The confinement of an excitation or interrogation pulse below one femtosecond now allows the direct observation of electronic motion in atoms and even solids on the atomic scales of time and length. One most fundamental effect of light-matter interaction is photoemission. Attosecond streaking spectroscopy allows to measure the relative time the arrival of photoexcited electrons at the solid-vacuum interface with precision on the 10 as level [1,2]. These experiments allow hitherto unknown insight into the nature of microscopic electronic transport and excitation at solid state surfaces.

The combination of attosecond streaking spectroscopy with techniques well known from surface science, such as the preparation of atomically thin adsorbate systems, allows the extension of photoemission spectroscopy towards determination of absolute timing of the photoemission process. In this talk I will present our recent results on energy-dependent relative and absolute photoemission time delays in tungsten [3] and magnesium [4], and discuss the particular link between the spectral and spatial distributions of the bound electronic states and the temporal dynamics of the fundamental excitations underlying photoemission.

[1] A. Cavalieri et al., Attosecond spectroscopy in condensed matter, *Nature* 449, 1029 (2007)
[2] M. Schultze et al., Delay in Photoemission, *Science* 328, 1658 (2010)
[3] M. Ossiander et al., Absolute timing of the photoelectric effect, *Nature* 561, 374 (2018)
[4] J. Riemensberger et al., Attosecond Dynamics of sp-Band Photo-Excitation, submitted (2019)