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Prof. Dr. Reinhard Kienberger
Technische Universität München

Absolute time delay of photoemission from solids

The generation of single isolated attosecond pulses in the extreme ultraviolet (XUV) together with fully synchronized few-cycle infrared (IR) laser pulses allowed the tracing of electronic processes on the attosecond timescales. In attosecond streaking [1], which is the most established technique in attosecond science, photoelectrons are generated by laser based attosecond extreme ultraviolet pulses (XUV) and are simultaneously exposed to a dressing electric field from well synchronized laser pulses. The energy shift induced by the dressing field is dependent on the delay between the XUV pulse and the dressing field, making it possible to measure the respective delay in photoemission between core electrons and conduction band electrons).

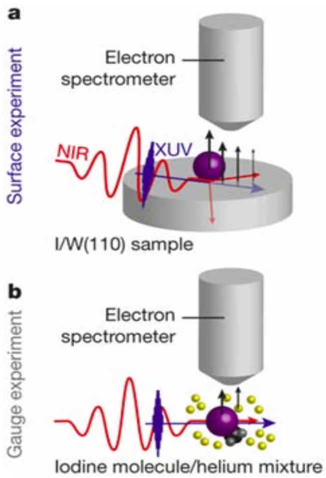

Fig. 1. (a) Surface experiment. An XUV light pulse launches photoelectrons from a W(110) surface (grey) and from an iodine chronoscope (purple) on top. An NIR laser pulse encodes the appearance time of photoelectrons as a momentum shift. (b) Gas-phase gauge experiment. The delay between photon absorption by the chronoscope and photoelectron appearance is determined by comparing to helium (yellow). (from [4]).

The information gained in such experiments on tungsten [2] triggered many theoretical activities leading to different explanations on the physical reason of the delay. Attosecond streaking experiments have been performed on different solids [3], leading to different delays – also depending on the excitation photon energy. I will discuss recent measurements that enable the characterization of time-resolved transport of different types of electrons through a defined number of adlayers on a bulk material on an attosecond timescale [3]. Finally a method based on sophisticated sub-monolayer-extrapolation will be reported that allows us to measure not only relative delays but the absolute time an electron needs to travel from one position to another [4].

References

[1] R. Kienberger *et al.*, Nature **427**, 817 (2004).
[2] A. Cavalieri *et al.*, Nature **449**, 1029 (2009).
[3] S. Neppl *et al.*, Nature **517**, 342 (2015).
[4] M. Ossiander *et al.*, Nature **561**, 374 (2018).

Einladender: Prof. Fennel