Attosecond spectroscopy on surfaces

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Over the past decade novel ultrafast optical technologies have pushed the duration of laser pulses close to its natural limit, to the wave cycle, which lasts somewhat longer than one femtosecond (1 fs = 10EXP-15 s) in the visible spectral range. Atoms exposed to a few oscillation cycles of intense visible or near-infrared light are able to emit a single XUV photon wavepacket of sub-femtosecond duration [1]. These XUV pulses together with the few-cycle (few-femtosecond) laser pulses used for their generation have opened the way to the development of a technique for attosecond sampling of electrons ejected from atoms or molecules [2]. This is accomplished by probing electron emission with the oscillating electric field of the few-cycle laser pulse following excitation of the atom by the synchronized sub-femtosecond XUV pulse. First experiments have been carried out to measure sub-femtosecond behavior of matter. Recently, the dynamics of the photoionization process on solids has been studied [3]. Not only that attosecond metrology now enables clocking of surface dynamics, but also the individual behaviour of electrons of different type (core electrons vs. conduction band electrons vs. adlayers) can be resolved. Here, we measured a time delay of about 100 as on the emission of the aforementioned types of electrons (see Fig. 1).

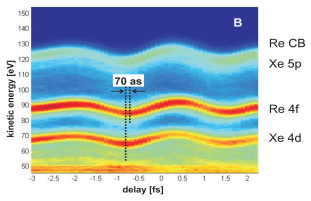

Figure 1: Spectrograms of Xe and Re electrons showing a delay in emission.

The information gained in these experiments may have influence on the development of many modern technologies including semiconductor and molecular electronics, optoelectronics, information processing, photovoltaics, electrochemical reactions, or electronically stimulated chemistry on surfaces and interfaces.

[1] M. Hentschel et al., Nature **414**, 501 (2001).

[2] R. Kienberger et al., Nature (London) **427**, 817 (2004).

[3] A. Cavalieri et al., Nature **449**, 1029 (2007).