Electronic and Lattice Dynamics from Attosecond soft-X-ray Spectroscopy

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Time resolving photo-induced structural changes in matter, requires the tracking of initial electronic excitations and their further connection and impact on the local structure. This is a challenging endeavor, as traditional techniques can only separately address either the electronic dynamics or the changes on the atomic structure. Thus, several different methods are typically combined to gain some understanding of the physics. One has however to be very careful when combining, e.g., frequency domain with time-domain methods as it is by no means guaranteed that the same state of the system is measured. Core-level K-shell X-ray absorption near edge structure spectroscopy (XANES) is a well-established method capable to extract information on the electronic and lattice structure of a material with state selectivity. Combining its capabilities with the temporal resolution provided by attosecond soft X-ray pulses produced via high-harmonic generation (HHG) could thus address this problem.

Here, we present such first measurement on graphite which provides simultaneous electronic and structural information with real-time resolution provided by using 165 as soft X-ray pulses [1,2] at the K-edge of carbon at 284 eV. We demonstrate the novel capabilities of attosecond core-level XANES by identifying the orbital contributions to the density of states simultaneously with the four characteristic bonding distances of graphite's hexagonal lattice [3]. We furthermore show first information of the simulatenous dynamics of electrons and holes, thus the the real time observation of both charge carriers, and the prospects for the concommittent coupling to the lattice within a single measurement.

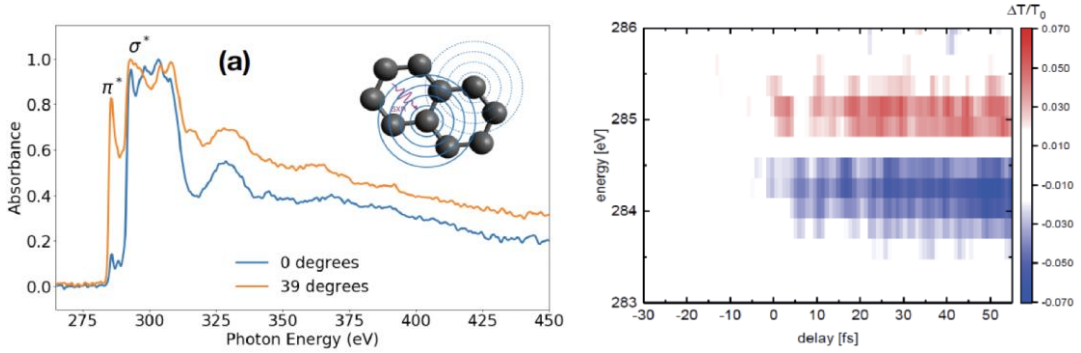

Figure 1: left XANES and EXAFS spectrum for graphite and for 2 different angles of incidence. Clearly identified are the π* and σ* antibonding states; **right** time-resolved XANES showing the temporal evolution of electrons and holes at the π-π* transition.

References

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