Ultrafast dynamics of complex materials probed by time-resolved photoemission

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The electronic properties of complex materials are often governed by strong electron-phonon coupling and many-body correlation effects leading to phenomena like metal-insulator transitions or superconductivity and the formation of broken symmetry ground states. One example for the coupling between electronic and phonon degrees of freedom are phase transitions in charge-density wave (CDW) materials where at low temperature a periodic lattice distortion leads to an opening of an electronic gap at the Fermi surface. Ultrafast optical excitation can induce non-equilibrium phase transitions as well as electronic and geometrical structure changes of such complex materials on femtosecond timescales.

We use time- and angle-resolved photoemission spectroscopy for a systematic study of the tri-telluride CDW system (RTe_3, R=Te, Ho, Dy) to probe directly the resulting transient evolution of the electronic structure and the collective phonon dynamics of the system through their influence on the quasiparticle band structure. In particular, we can directly map the transient changes of the Fermi surface and the opening and closing of the CDW gap. Furthermore, we use this technique to study the dynamics of electron relaxation and exciton formation at the ZnO(10-10) surface, where hydrogen termination leads to the formation of a two-dimensional electron gas (2DEG).