Momentum-Resolved View of Ultrafast Dynamics of Electrons, Excitons and Phonons in Layered Semiconductors

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We investigate basic material properties like electronic and atomic structure of crystalline materials in laser-prepared non-equilibrium states with time- and angle-resolved photoelectron spectroscopy (trARPES) and femtosecond electron diffraction (FED). The momentum-resolved view of the structure and dynamics of excited electrons and phonons provides information on microscopic coupling phenomena, e.g. the coupling of electronic and vibrational degrees of freedom. We aim for a quantum-state-resolved picture of coupling on the level of quasi-particle self-energies, which goes beyond established ensemble-average descriptions. I will exemplify this experimental approach by discussing electron, exciton and phonon dynamics in the semiconducting transition metal dichalcogenide WSe_2. TrARPES reveals the excited state band structure, the *k*-space distribution, energy and evolution of excitons and single-particle excited states. In addition, we demonstrate the optical preparation of spin- and pseudospin-polarized excited states in this centrosymmetric semiconductor [1]. The complementary momentum-resolved view on phonon dynamics is obtained by FED [2]. By combining this information, a microscopic picture of electron-lattice coupling and energy dissipation emerges.

References:
[1] R. Bertoni et al., Phys Rev. Lett. 117, 277201 (2016).
[2] L. Waldecker et al., Phys. Rev. Lett. 119, 036803 (2017).

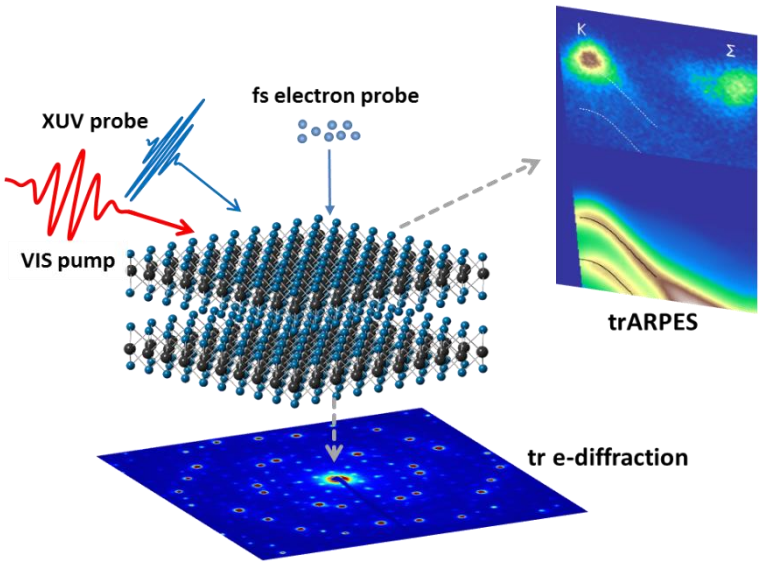

Illustration of the experimental approaches used for obtaining momentum-resolved information on the ultrafast dynamics of electrons and phonons and for revealing electron-phonon coupling.