Non-equilibrium carrier-lattice interactions in two-dimensional homo- and heterosystems studied with time- and angle-resolved photoemission

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The interaction between electronic and vibrational degrees of freedom is of central importance for various properties of solids. This includes very general phenomena such as charge and heat transport, but also phenomena such as the occurrence of low-temperature superconductivity, the formation of charge-order phases in 2D quantum materials, or energy and charge transfer processes across solid interfaces. The investigation of non-equilibrium dynamics in solids using time-resolved pump-probe spectroscopy techniques offers new and unique opportunities for a deeper understanding of this central interaction mechanism. Time- and angle-resolved photoemission allows an extremely direct view of these processes from the perspective of the electronic system [1]. In the talk, I will use various examples to explain how this technique can be used to address such questions in a targeted manner. Using the example of the Weyl semimetal candidate $WeTe_2$, I will illustrate how the coherent and selective excitation of phonon modes changes the electronic structure of the material on ultrashort time scales in its symmetry-determined properties [2]. I will further present results on the influence of the phonon background on the energy and momentum relaxation of excited carriers in graphite [3] and graphene hetrosystems. Finally, I will present a photoemission-based time-resolved diffraction technique developed by us, with which we can directly observe electronic and vibronic surface-adsorbate interaction processes at a time resolution of 100 femtoseconds [4].

[1] F. Boschini et al., Rev. Mod. Phys. **96**, 015003 (2024).
[2] P. Hein et al., Nat. Commun. **11**, 2613 (2020).
[3] H. Beyer et al., Phys. Rev. B **107**, 115136 (2023).
[4] H. Erk et al., arXiv:2404.14297