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Understanding electron-boson coupling in high temperature superconductors using time-resolved photoemission.

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Time- and angle-resolved photoelectron spectroscopy (trARPES) is a powerful technique for studying non-equilibrium properties of high temperature superconductors. The access to electronic band structure upon optical excitation enables a detailed investigation of the temporal evolution of photo-excited carriers. With strong optical excitations changing electronic properties non-adiabatically, coherent phonon modes can also be launched and detected. We employed trARPES to study both the copper- and iron-based high temperature superconductors. In optimally doped Bi2212, we find that the trARPES-derived population lifetimes deviate from the ARPES-derived single-particle lifetimes by one to two orders of magnitude [1]. This disparity can only be understood if processes beyond electron-phonon interactions play a significant role in the electron dynamics. In FeSe/SrTiO3 systems, we observe an abrupt phonon frequency renormalization in the monolayer FeSe as compared to thicker films [2]. This result sets the basis to quantitatively understand the interfacial lattice strain. Combining the collective response of the electronic bands with information about the underlying coherent lattice motion measured by time-resolved X-ray diffraction, we develop a fundamental understanding of the electron-phonon coupling in FeSe [3]. These examples demonstrate some remarkable microscopic insights on electronic and phononic properties which can only be accessed by trARPES. [1] S.-L. Yang et al. Phys. Rev. Lett. 114, 247001 (2015) [2] S.-L. Yang et al. Nano Lett. 15, 4150 (2015) [3] S. Gerber et al. in preparation (2015)