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Signatures of electron-boson coupling in the time domain: beyond the equilibrium interpretation

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A powerful method to study the interactions between electrons and bosons in high-Tc superconductors is the measurement of the single-particle spectral function. The recent development of time-resolved ARPES (tr-ARPES) has allowed this measurement of be performed out of equilibrium, where the material is driven by an ultrafast laser pump pulse. We have developed a theoretical framework to complement to these experiments, and here we report on several aspects of electron-boson coupling out of equilibrium. First, we will illustrate how time-resolved spectroscopy can be used to study the coupling between electrons and phonons observing the decay rate of the transient signals as a function of energy, momentum, and time. A sufficiently strongly coupled phonon will exhibit a signature in the tr-ARPES spectra as both a kink in the dispersion as well as a sharp change of the decay rates, and we will discuss how these effects appear out of equilibrium. [1][2]

Second, we will focus on the return to equilibrium in systems with multiple interaction types, and show that there are two distinct types of scattering processes: those types of interactions that conserve the energy within a subsystem, and those that do not. While in equilibrium these two contribute equally to the linewidth, we will show that out of equilibrium they behave differently – the first type are mainly responsible for thermalization within the electronic subsystem, whereas the second type drain the energy out. As a result, the scattering rates out of equilibrium can be vastly different from the linewidth, and the features of the second type of interactions can be clearly observed.[3][4]

1. M. Sentef et al., Phys. Rev. X 3, 041033 (2013)
2. A.F. Kemper et al., Phys. Rev. B 90, 075126 (2014)
3. S.L. Yang et al., Phys. Rev. Lett. 114, 247001 (2015)
4. J. Rameau et al., arXiv:1505.07055