Direct determination of mode-projected electron phonon coupling in the time domain

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The development of high-intensity ultrafast lasers has allowed the extension of many experimental techniques into the time domain [1]. These techniques have become crucial tools for expanding our understanding of both equilibrium and non-equilibrium phenomena. In particular, time- and angle-resolved photoemission spectroscopy (TR-ARPES) can directly access the dynamical electronic structure. By simultaneously resolving energy, momentum, and time, TR-ARPES can infer coupling between electrons and collective modes by the scattering timescales or the evolution of the electronic distribution [2, 3, 4].

We have developed a femtosecond extreme ultra-violet (XUV) light source with an emphasis on energy-resolution (20~meV) and repetition rate (60~MHz), to enable detailed study of the evolution of non-thermal spectral features [5]. Within these non-thermal features, we show that TR-ARPES can resolve signatures of specific electron-phonon scattering events. Using graphite as a prototypical example, we demonstrate a technique for extracting the mode-projected electron-phonon matrix element – for well-defined electron initial and final states – from TR-ARPES data [4]. Our study emphasizes the need for models of electron dynamics that move away from the thermal description of the electronic distribution, which relies on assumptions that have been shown to be invalid at early delays [3]. Instead, microscopic scattering processes must be considered in the description of the coupling between electrons, lattice and other collective modes.

References:

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