A Spectroscopic View of Electron-Phonon Coupling

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Electron-phonon interaction in metals is a very old subject. Göran Grimvall in the preface to his classic book on this subject pointed out that 1000 papers had been published on this subject between 1960 and 1980 [1]. What can be new and exciting in such an old and mature field? The answer is *surfaces and surface science* techniques. Recent advances in experimental techniques coupled with ever-growing theoretical capabilities promise to create a renaissance in this subject. High-resolution angular-resolved photoemission is producing direct images of the distortion of the two-dimensional surface state bands near the Fermi energy caused by electron-phonon coupling (EPC). First-principles calculations of the EPC for surface states are appearing in the literature [2, 3] which not only explain the origin of the EPC-induced band distortions but also produce exquisite pictures of the Eliashberg function $\alpha^2F(w)$ [1]. The Eliashberg function is the product of a coupling constant (λ) times the phonon density of states and is at the heart of any theory of EPC [1]. A recent theoretical advance that will be described in this talk will allow experimentalists to extract the Eliashberg function directly from the high-resolution photoemission data [4]. These developments mark the beginning of a new era or a renaissance in the elucidation of many-body effects in reduced dimensionality.

In the 1960s the most definitive signature for determining the mechanism in conventional superconductors was the measurement of the single-particle tunneling I-V characteristic and the concomitant inversion procedure to display the Eliashberg function. Today EPC is intimately associated with the functionality of complex materials and its role in high-T_C superconductivity is being actively discussed. Research on metal surfaces can produce in unprecedented detail a picture of electron-phonon coupling. The Eliashberg function can be measured as a function of both E and **k** and related directly to measured and calculated surface phonon dispersion curves. Several recent examples will be used to illustrate the detailed spectroscopic information that can be extracted from the high-resolution angle-resolved photoemission data.

These investigations on surfaces of relatively simple metals can be the platform for understanding functionality in complex materials associated with the coupling between charge and the lattice. Several examples will be given to illustrate the power of the unfolding technique [4] by displaying the extracted Eliashberg function from experimental data on High-T_c superconductors, magnetic thin films, and charge-density-wave stabilized two-dimensional 2H-$TaSe_2$ [5].

References:

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