Universal and Material-Specific Properties of the Copper Oxide Superconductors

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The family of copper oxide high temperature superconductors consists of several compounds which vary in their elemental composition, except for the common CuO_2 planes, were the relevant electronic excitations take place. However the elemental composition beyond these CuO_2 planes varies greatly. It is therefore not too surprising that a wide range of both experimental and theoretical points of view have appeared in the literature. Leggett[1], using the large body of experimental evidence, has summarized the most fundamental properties of the cuprate superconductors, independent of any theoretical model. Here, we attempt to connect the nature of the electronic excitations, as observed by angle resolved photoemission, to the fundamental properties discussed by Leggett[1], adding additional points that are generic to all copper oxide superconductors. We further show that some of the discrepancies in the literature result from changes introduced into the composition, in an attempt to induce a particular compound to cover the entire range of the doping-temperature phase diagram.A dramatic change in energy gap anisotropy upon reducing carrier concentration has often been observed in the copper-oxide superconductors. A simple *d*-wave gap in materials with the highest superconducting T_c evolves with underdoping into a "two-gap" behavior, with different **k**-dependences in different regions of momentum space. It is tempting to associate the large antinodal gap, that persists even above T_c in underdoped materials, with a second order parameter distinct from *d*-wave superconductivity. We use angle-resolved photoemission spectroscopy (ARPES) to show that the two-gap behavior, and the concomitant destruction of well defined electronic excitations, are not universal features of high temperature superconductors, and depend sensitively on how the underdoped materials are prepared. Depending on cation substitution, underdoped crystals either show two-gap behavior or not. In contrast, many characteristics of HTSC like the superconducting dome (Tc versus doping), nodal quasiparticles, antinodal gap that decreases monotonically with doping, and the pseudogap, are present in all samples, irrespective of whether they exhibit two-gap behavior or not. Our results imply that universal aspects of high Tc superconductivity are insensitive to differences in the electronic states in the antinodal region of the Brillouin zone.

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References

1) A. Leggett, What DO we know about high *Tc?* Nature Physics **2** (2006) 134.