TT 10: Superconductivity - Properties, Electronic Structure, Order Parameter

Time: Tuesday 9:30–13:00 Location: H18

TT 10.1 Tue 9:30 H18

Opening of the Superconducting Energy Gap observed with Neutron Spectroscopy — •Frank Weber[1,2], Andreas Kreyssig[3,4], Lothar Pintschovius[1], Winfried Reichardt[1], Oliver Stockert[5], Rolf Heid[1], Dmitry Reznik[1], and Klaudia Hradil[6] — [1]FZ Karlsruhe, IFP, Karlsruhe — [2]PI, Uni Karlsruhe (TH), Karlsruhe — [3]IFP, TU Dresden, Dresden — [4]Ames Laboratory, Ames, USA — [5]MPI-cpfs, Dresden — [6]IPC, Uni Göttingen, Aussenstelle FRM II, Garching

We present inelastic neutron scattering data on YNi_2B_2C ($T_c = 15$ K). We made a systematic study of the already known phonon anomaly in the (100)-direction [1] as well as of a so far unexplored anomaly at the zone boundary in the (110)-direction (M-point). Our data unambiguously show that the superconductivity-induced changes of the spectral function of phonons with a strong electron-phonon coupling can extremely well be understood in the framework of a theory proposed by Allen et al. [2]. The analysis yields the temperature dependent SC energy gap with high accuracy. As a consequence, even deviations from BCS like behavior can be assessed with confidence. Further, we found that the SC gap extracted from the phonon data for q=(0.5,0,0) and q=(0.5,0.5,0), respectively, differs by a factor 1.4. This is a direct proof for the long discussed anisotropy of the SC energy gap in borocarbides.

[1] Kawano et al., PRL. 77, 4628 (1996), [2] Allen et al., PRB 56, 5552 (1997)

TT 10.2 Tue 9:45 H18

Electron Spin Dynamics of the Novel Superconductor CaC_6 probed by ESR — •Ferenc Murányi, Grzegorz Urbanik, Vladislav Kataev, and Bernd Büchner — Leibniz Institute for Solid State and Materials Research Dresden, 01171 Dresden, PO BOX 270116, Germany

The Conduction Electron Spin Resonance (CESR) was measured on a thick slab of polycrystalline CaC_6 in the normal and superconducting state. The measurements characterize the metallic properties in the normal state and indicates the description of superconductivity in the dirty limit. Magnetic field dependent nonlinear absorption in the superconducting state evidenced the anisotropy of H_{c2}. Superconducting state measurements revealed the increase of effective skin depth below T_c.

TT 10.3 Tue 10:00 H18

Phonon anomalies in detwinned $YBa_2Cu_3O_{7-x}$: Strong *ab*-anisotropy in the phonon vibrations — •M. Bakr, C. Ulrich, J. Unterhinninghofen, D. Manske, C. Lin, and B. Keimer — Max-Planck-Institute for Solid State Research, Stuttgart, Germany

We have used Raman light scattering to investigate the electronic signal and phonon anomalies in detwinned optimally doped $YBa_2Cu_3O_{7-x}$ single crystals. Within the experimental error bar, no changes in the electronic gaps was observed with respect to the a and b axes. This is in contrast to previous experimental results observed by ARPES data and Josephson current measurements. All phonons show a pronounced asymmetry, i.e. Fano-profile, which indicates a strong electron-phonon interaction. A pronounced anisotropy in the asymmetry is observed with respect to the crystallographic a and b axes. This anisotropy appears for example for the 340 cm^{-1} phonon, but the 501 cm^{-1} phonon shows the largest difference. It is interesting to note that this phonon is right at the energy of the $2\Delta_{max}$ gap. The anisotropy of the asymmetry parameter, 1/q, is already present in the normal state. Below T_c, the 1/q changes drastically and in a characteristic way for the a and b axes. Finally, we compare our results with Fermi-liquid based calculations. Our results provide further insight into the electron-phonon interaction and therefore the electronic system of high T_c superconductors.

TT 10.4 Tue 10:15 H18

Theory for ultrafast dynamics in cuprates: Role of electron-phonon coupling — •Julia Unterhinninghofen[1], Dirk Manske[1], and Andreas Knorr[2] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart — [2]Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

We present a theory for ultrafast nonequilibrium dynamics in cuprate superconductors. In a typical time-resolved spectroscopy experiment, the sample is exited with an intense laser pulse, creating nonequilibrium quasiparticles which subsequently can relax via various scattering processes, restoring the superconducting state. We use the method of density matrix theory to study the optical excitation and relaxation dynamics in cuprates from a microscopical viewpoint. In particular, we consider scattering with optical phonons, looking at the interplay between relaxation of the excited quasiparticles and the creation of nonequilibrium phonon distributions; the superconducting state is restored on a 10 picosecond timescale, while the phonons have longer relaxation times. Time-resolved pump-probe spectra are calculated and compared both to quasi-equilibrium models and experimental results.

TT 10.5 Tue 10:30 H18

Charge(re)distribution at YBCO/metal interfaces: screened band bending — •Cosima Schuster and Udo Schwingenschlögl — Institut für Physik, Universität Augsburg, 86135 Augsburg

The functionality of nanoscale devices depends crucially on the transport properties across the interfaces. Especially, the transport mechanism in electronic devices based on high-T_c-superconductors is of special interest, in particular the charge density within the superconducting CuO_2 planes in the vicinity of an interface or grain boundary. Main questions in this context are interface charging, band bending, or contact resistivity. We calculate the local electronic structure of an YBCO/metal interface using density functional theory (using the Wien2k code) in two different geometries (where the interface is either parallel or perpendicular to the CuO_2 planes), including an optimization of the atomic positions near the interface. We consider supercells with 4 metal and 2 YBCO or 6 metal and 3 YBCO units, respectively. For the parallel contact we find a transfer of holes out of the CuO_2 planes resulting in shift to the underdoped regime of the high-T_c phase diagram. Thus, this geometry reflects the properties of a grain boundary. The results are neither dependent on contact geometry, nor the contact metal, or interface plane.

TT 10.6 Tue 10:45 H18

First principles Thermodynamics of $YBa_2Cu_3O_7$ — Volker Pankoke[1,2], •Rolf Heid[1], and Klaus-Peter Bohnen[1] — [1]Forschungszentrum Karlsruhe, Institut für Festkörperphysik — [2]Forschungszentrum Karlsruhe, Institut für Wissenschaftliches Rechnen

Modern density-functional based methods nowadays allow for an accurate calculation of phonon spectra and their dependence on structural parameters, which is a prerequisite for the study of finite temperature properties based on the free energy. Due to the large numerical costs, however, ab initio studies of thermodynamic properties have been restricted in most cases to crystals with simple lattice structures.

We will present an application of this ab initio approach to the cuprate superconductor $YBa_2Cu_3O_7$ with its rather complex crystal structure. Thermodynamical properties are calculated within the quasiharmonic approximation using phonon spectra obtained by density functional perturbation theory. We will discuss results for the anisotropic thermal expansion and specific heat in comparison with experiment to assess the accuracy of this approach.

TT 10.7 Tue 11:00 H18

Terahertz spectroscopy of electron-doped superconductors in magnetic field — •Artem V. Pronin[1], Andrei Pimenov[2,3], Alois Loidl[2], Akio Tsukada[4,5], and Micho Naito[4] — [1]Hochfeld-Magnetlabor Dresden (HLD), Forschungszentrum Dresden-Rossendorf, 01314 Dresden, Germany — [2]Experimentalphysik V, EKM, Universität Augsburg, 86135 Augsburg, Germany — [3]Experimentelle Physik 4, Universität Würzburg, 97074 Würzburg, Germany — [4]Department of Applied Physics, Tokyo University of Agriculture and Technology, 2-24-16, Naka-cho, Koganei, Tokyo 184-8588, Japan — [5]NTT Basic Research Laboratories, NTT Corporation, 3-1 Morinosato-Wakamiya, Atsugi, Kanagawa 243-0198, Japan

In the terahertz and infrared regions we measured the optical conductivity and penetration depth of the electron-doped cuprate superconductor $La_{2-x}Ce_xCuO_4$. In the frequency-temperature behavior of conductivity we observe remarkable differences between the samples with different Ce content, suggesting the gap anisotropy to be a func-