TT 2: SC: Properties, Electronic Structure, Mechanisms 1

Time: Monday 10:30–13:00 Location: HSZ 301

TT 2.1 Mon 10:30 HSZ 301

Shubnikov-de Haas effect and angle-dependent magnetoresistance oscillations in the electron-doped cuprate superconductor $Nd_{2-x}Ce_xCuO_4$ — •Toni Helm[1], Carsten Putzke[2], Mark V. Kartsovnik[1], Nikolaj Bittner[1], Frederik Wolff-Fabris[2], Iliya Sheikin[3], Cyril Proust[3], Andreas Erb[1], Jochen Wosnitza[2], and Rudolf Gross[1] — [1]Walther-Meissner-Institute, Garching, Germany — [2]Dresden High Magnetic Field Laboratory, Dresden-Rossendorf, Germany — [3]Laboratoire National des Champs Magnétiques Intenses, Grenoble/Toulouse, France

High-field magnetotransport has recently proved extremely efficient for elucidating the Fermi surface of cuprate superconductors. By applying sufficiently high magnetic fields superconductivity is suppressed and the normal-conducting state can be accessed for even lowest temperatures. We observed quantum oscillations of the magnetoresistance, the Shubnikov-de Haas (SdH) effect, in the electron-doped cuprate $Nd_{2-x}Ce_xCuO_4$. A dramatic change in the oscillation spectrum was found, revealing a transformation of the cyclotron orbit topology at a critical doping level. On the other hand, angle-dependent magnetoresistance oscillations (AMRO) did not show an appreciable change in the same doping range. In this talk we present new results on the AMRO and SdH oscillations obtained at higher magnetic fields for single crystals with x ranging from 0.145 to 0.17. Our data provides a compelling evidence for a translational symmetry breaking persisting in the material up to highest doping level.

TT 2.2 Mon 10:45 HSZ 301

Momentum-Resolved Ultrafast Electron Dynamics in Superconducting $Bi_2Sr_2CaCu_2O_{8+\delta}$ — •L. Rettig[1,2], R. Cortes[1,3], Y. Yoshida[4], H. Eisaki[4], M. Wolf[3], and U. Bovensiepen[2] — [1]Fachb. Physik, Freie Univ. Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fak. f. Physik, Univ. Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany — [3]Abt. Phys. Chemie, Fritz-Haber-Institut d. MPG, Faradayweg 4-6, 14195 Berlin, Germany — [4]Nat. Inst. of Adv. Industrial Science and Technology, Tsukuba, Ibaraki 305-8568, Japan

The processes responsible for the relaxation of hot quasiparticles (QPs) in high-T_c superconductors have been intensely studied by time-resolved optical and THz spectroscopy. These studies conclude on highly momentum dependent dynamics, which however cannot be resolved directly by these momentum integrating techniques.

Here, we report on the non-equilibrium state of the high-T_c superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ and its ultrafast dynamics investigated by femtosecond time- and angle-resolved photoemission spectroscopy. This technique allows direct investigation of excited QPs and the dynamics of the superconducting state with both momentum and energy resolution. Thus, we are able to investigate optically excited QPs at different electron momenta along the Fermi surface and detect metastable QPs near the antinode. Their decay through e-e scattering is blocked by a scattering phase space restricted to the nodal region. We find a single exponential relaxation of the excited QPs with momentum independent decay rates, in agreement with relaxation dominated by Cooper pair recombination in a boson bottleneck limit.

TT 2.3 Mon 11:00 HSZ 301

The energy scale in the cuprates: a Raman study — •B. Muschler[1], N. Munnikes[1], F. Venturini[1], L. Tassini[1], W. Prestel[1], Shimpei Ono[2], Yoichi Ando[3], A. Damascelli[4], D. Peets[4], W.N. Hardy[4,5], R. Liang[4,5], D. Bonn[4,5], H. Eisaki[6], M. Greven[7], A. Erb[1], and R. Hackl[1] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]CRIEPI, Komae, Tokyo 201-8511, Japan — [3]Institute of Scientific and Industrial Research, Osaka University, Ibaraki, Osaka 567-0047, Japan — [4]Department of Physics & Astronomy, University of British Columbia, Vancouver, BC V6T 1Z4, Canada — [5]Canadian Institute for Advanced Research, Toronto M5G 1Z8, Canada — [6]Nanoelectronic Research Institute, AIST, Tsukuba 305-8568, Japan — [7]Department of Applied Physics and Photon Science, Stanford University, Stanford, CA 94305, USA

We present results of electronic Raman scattering experiments in single crystals of YBCO, Bi2212 and Tl2201 in the superconducting state. In B_{2g} symmetry we find universal, material independent spectra with the pair breaking peak $\Omega^{B2g}_{\rm peak}$ scaling as $6\,k_BT_c$. $\Omega^{B1g}_{\rm peak}$ depends on the individual samples and may change by up to 30% for samples with the same T_c. On the average $\Omega^{B1g}_{\rm peak}$ decreases from $9\,k_BT_c$ to $4.5\,k_BT_c$ with the doping level increasing from $p = 0.15$ to $p = 0.23$. While the spectral weights of the B_{2g} peaks are doping independent those in B_{1g} increase by almost a factor of 10 from optimal to overdoped samples.

This work is supported by the DFG via FOR538 and SPP1458.

TT 2.4 Mon 11:15 HSZ 301

Low-energy kink in the nodal dispersion of copper-oxide superconductors: Insights from Dynamical Mean Field Theory — •Johannes Bauer[1] and Giorgio Sangiovanni[2] — [1]Max-Planck Institute for Solid State Research, Heisenbergstr.1, 70569 Stuttgart — [2]Institute of Solid State Physics, Vienna University of Technology, 1040 Vienna, Austria

Motivated by the observation in copper-oxide high-temperature superconductors, we investigate the appearance of kinks in the electronic dispersion due to coupling to phonons for a system with strong electronic repulsion. We study a Hubbard model supplemented by an electron-phonon coupling of Holstein type within Dynamical Mean Field Theory (DMFT) utilizing Numerical Renormalization Group as impurity solver. Paramagnetic DMFT solutions in the presence of large repulsion show a kink only for large values of the electron-phonon coupling λ or large doping and, contrary to the conventional electron-phonon theory, the position of such a kink can be shifted to energies larger than the renormalized phonon frequency ω_0^r. When including antiferromagnetic correlations we find a stronger effect of the electron-phonon interaction on the electronic dispersion due to a cooperative effect and a visible kink at ω_0^r, even for smaller λ [1]. Our results provide a scenario of a kink position increasing with doping, which can be related to recent photoemission experiments on Bi-based cuprates.

[1] J. Bauer and G. Sangiovanni, Phys. Rev. B. 82, 184535 (2010).

TT 2.5 Mon 11:30 HSZ 301

Pairing theory of striped superconductivity — •Florian Loder, Arno P. Kampf, Thilo Kopp, and Siegfried Graser — Center for Electronic Correlations and Magnetism, Institute of Physics, D-86135 Augsburg, Germany

Striped high-T_c superconductors such as $La_{7/8}Ba_{1/8}CuO_4$ show a fascinating competition between spin and charge order on the one hand and superconductivity on the other. A theory for these systems therefore has to capture both the spin correlations in an antiferromagnet and the pair-correlation of a superconductor. For this purpose we have developed an effective Hartree-Fock theory by merging electron pairing with finite center-of-mass momentum and antiferromagnetism. We show that this theory reproduces the key experimental features such as the formation of the antiferromagnetic stripe patterns at 7/8 band filling or the quasi one-dimensional electronic structure observed by photoemission spectroscopy.

15 min. break

TT 2.6 Mon 12:00 HSZ 301

Charge stripe order near the surface of 12-percent doped $La_{2-x}Sr_xCuO_4$ — •M. Buchholz[1], H.-H. Wu[1,2], C. Trabant[1,4], C.-F. Chang[1], A. Komarek[1], F. Heigl[3], E. Schierle[4], M. v. Zimmermann[5], M. Cwik[1], F. Nakamura[6], L. H. Tjeng[7], M. Braden[1], and C. Schüssler-Langeheine[1,4] — [1]II. Physikalisches Institut, Universität zu Köln — [2]NSRRC, Hsinchu, Taiwan — [3]ALBA, Barcelona, Spain — [4]Helmholtz-Zentrum Berlin — [5]DESY, Hamburg — [6]ADSM, Hiroshima University, Japan — [7]MPI CPfS, Dresden

Stripe-like spin and charge order has been observed in many layered cuprate, nickelate and cobaltate systems by neutron or x-ray diffraction. For the prototypical high-temperature superconductor $La_{2-x}Sr_xCuO_4$ (LSCO) no charge-stripe signal has been found so far, but there are several indications for a proximity to the formation of charge stripes. We found a pronounced charge-stripe signal in the near surface region of 12-percent doped LSCO, but no such signal from the bulk. We conclude that this compound is so close to the formation of charge stripes that small perturbations near the surface can stabilize this order. Our finding of different phases in the bulk and near the surface of LSCO has to be taken into account for the interpretation of data from surface-sensitive probes like photoelectron spectroscopy or scanning tunnelling spectroscopy.

TT 2.7 Mon 12:15 HSZ 301

Electronic structure of striped phase of $Ca_{1.875}Na_{0.125}CuO_2Cl_2$

— •Charles Patterson — Trinity College Dublin, Ireland

We present hybrid DFT calculations on stripe formation in hole doped $Ca_2CuO_2Cl_2$ (CCOC) [1]. Stripes have been extensively studied by STM in sodium-doped CCOC with hole concentrations, x, in the range x = 0.05 to x = 0.15 per Cu ion [2]. Around x = 0.125, 1-D stripes are observed with a spacing of four lattice constants. STM imaging in topographic mode allows positions of Cl ions and Cu ions directly beneath to be observed. Stripes imaged in conductance mode are centred on O ions in rows running perpendicular to the stripe direction, i.e. they are bond centred stripes on O ions.

O ions between transition metal ions with a magnetic moment induce anti-ferromagnetic coupling between the metal ion magnetic moments via super-exchange. However, when a hole is localized on the O ion between two transition metal magnetic moments, it induces ferromagnetic coupling between the metal ion magnetic moments by double-exchange. We propose a magnetic order for Cu ion spins and hole localisation on O ions in the CuO_2 layers of CCOC with x = 0.125. Holes are localised in rows on O ions, separated by four lattice constants; each pair of Cu magnetic moments on either side of an O ion with a localized hole are parallel and each pair of Cu magnetic moments on either side of an ordinary O ion are anti-parallel, satisfying the rules for super- and double-exchange.

[1] C. H. Patterson, Phys. Rev. B 77, 094523 (2008).
[2] Y. Kohsaka et al, Science 315, 1380 (2007).

TT 2.8 Mon 12:30 HSZ 301

Effects of High Pressure on $YBa_2Cu_4O_8$ probed by ^{17}O NMR

— •Thomas Meissner[1], Swee K. Goh[2,3], Jürgen Haase[1], and Grant V. M. Williams[4] — [1]Faculty of Physics and Earth Science, University of Leipzig, Germany — [2]Department of Physics, Cavendish Laboratory, University of Cambridge, United Kingdom — [3]Trinity College, Cambridge, United Kingdom — [4]The MacDiarmid Institute and Industrial Research Limited, New Zealand

The application of gigapascal pressure is a useful tool to tune the physical properties of high temperature superconductors but its effects have been scarcely studied by nuclear magnetic resonance (NMR) due a limited signal to noise ratio. Recently, some of us showed that this problem could be overcome with a new anvil cell probe design. Here we report on measurements of the ^{17}O Knight shifts in the normal state of the stoichiometric compound $YBa_2Cu_4O_8$ at pressures up to 6.3 GPa. Our data implies a significant pressure induced change of the spin susceptibility at the planar oxygen sites. The results are compared with doping effects observed in other cuprates.

TT 2.9 Mon 12:45 HSZ 301

Change of critical temperature by electric fields

— •Klaus Morawetz[1,2], Pavel Lipavský[3], Jan Kolaček[4], and Ernst Helmut Brandt[5] — [1]University of Applied Science Münster, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — [2]International Institute of Physics (IIP), Universidade Federal do Rio grande do Norte - UFRN, Brazil — [3]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 12116 Prague 2, Czech Republic — [4]Institute of Physics, Academy of Sciences, Cukrovarnická 10, 16253 Prague 6, Czech Republic — [5]Max Planck Institute for Metals Research, D-70506 Stuttgart, Germany

Electrostatic charging changes the critical temperature of superconducting thin layers. To understand the basic mechanism, it is possible to use the Ginzburg-Landau theory with the boundary condition derived by de Gennes from the BCS theory. Here we show that a similar boundary condition can be obtained from the principle of minimum free energy. We compare the two boundary conditions and use the Budd-Vannimenus theorem as a test of approximations. Resulting consequences on measurable surface potentials and surface deformations are discussed and a new effect of discontinuity of the magnetocapacitance near H_{c3} is presented.

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