TT 25: Superconductivity: Cuprate High-Temperature Superconductors 1

Time: Wednesday 9:30–13:00 Location: HSZ 304

TT 25.1 Wed 9:30 HSZ 304

Stripe-like charge order in $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$ studied by resonant soft X-ray diffraction — •Jörg Fink[1,2], Enrico Schierle[1], Viktor Soltwisch[1], Eugen Weschke[1], Hermann Dürr[1], Jochen Geck[2,3], Patrick Ribeiro[2], Bernd Büchner[2], David Hawthorn[3], and George Sawatzky[3] — [1]Helmholtz Zentrum Berlin — [2]IFW Dresden — [3]University of British Coulombia, Vancouver, Canada

In the doped cuprates there exists a complex interplay between lattice, charge and spin degrees of freedom leading to the appearance of stripe phases. In the stripe phases antiferromagnetic antiphase magnetic domains are separated by periodically spaced domain walls to which the holes segregate. We used resonant soft X-ray scattering with photon energies near the O K and the Cu L3 edges to study the charge ordering in the system $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$. This method is the only one in which static charge ordering can be directly detected. A complete phase diagram could be derived for the charge ordering which will be compared with structural and spin ordering. In addition,information on the amplitude and on the doping dependence of the wave lenght of the charge ordering is provided. The results support strong coupling scenarios for the mechanism of stripe formation.

TT 25.2 Wed 9:45 HSZ 304

Evidence for Fermi surface reconstruction in the static stripe phase of $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$, $x = 1/8$ — •V. B. Zabolotnyy[1], A. A. Kordyuk[1,2], D. S. Inosov[1,3], D. V. Evtushinsky[1], R. Schuster[1], B. Büchner[1], N. Wizent[1], G. Behr[1], S. Pyon[4], T. Takayama[4], H. Takagi[4], R. Follath[5], and S. V. Borisenko[1] — [1]Institute for Solid State Research, IFW-Dresden, P.O.Box 270116, D-01171 Dresden, Germany — [2]Institute of Metal Physics of National Academy of Sciences of Ukraine, 03142 Kyiv, Ukraine — [3]Max-Planck-Institut für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart, Germany — [4]Department of advanced materials, University of Tokyo, Kashiwanoha 5-1-5, Kashiwa 277-8561, Japan — [5]BESSY GmbH, Albert-Einstein-Strasse 15, 12489 Berlin, Germany

We present a photoemission study of $La_{0.8-x}Eu_{0.2}Sr_xCuO_4$ with doping level x=1/8, where the charge carriers are expected to order forming static stripes. Though the local probes in direct space seem to be consistent with this idea, there has been little evidence found for such ordering in quasiparticle dispersions. We show that the Fermi surface topology of the 1/8 compound develops notable deviations from that observed for $La_{2-x}Sr_xCuO_4$ in a way consistent with the FS reconstruction expected for the scattering on the antiphase stripe order.

TT 25.3 Wed 10:00 HSZ 304

Renormalization of the longitudinal bond-stretching phonon branch in $La_{1.95}Sr_{0.05}CuO_4$ probed by inelastic neutron scattering technique — •A. Hamann[1], D. Lamago[1,2], L. Pintschovius[1], K. Yamada[3], M. Fujita[3], and D. Reznik[1,2] — [1]Institut für Festkörperphysik, KIT, 76021 Karlsruhe, Germany — [2]LLB, CEA Saclay, 99191 Gif sur Yvette, France — [3]Institute for Materials Research, Tohoku Univ., Katahira, Sendai 980-8577, Japan

$La_{2-x}Sr_xCuO_4$ becomes superconducting (sc) for $0.06 \leq x < 0.3$, where optimal doping of $x = 0.15$ results in T_c up to 38 K. The mechanism leading to SC remains to be understood. Neutron scattering experiments revealed anomalous phonon behavior that hints at an enhanced electron-phonon coupling possibly connected to dynamic stripe order [1].

We report our latest measurements on non-sc $La_{1.95}Sr_{0.05}CuO_4$. Shell model predictions including resolution effects were used to fit the data. We found that in comparison to the sc-samples the anomalous phonon behavior becomes much less pronounced.

[1] D. Reznik et al., Nature **440**, 1170 (2006)

TT 25.4 Wed 10:15 HSZ 304

Charge stripes and electron phonon coupling in cuprates — •A. C. Komarek[1], A. Hiess[2], H. Hiraka[3], K. Ikeuchi[3], M. v. Zimmermann[4], M. Fujita[3], K. Yamada[3], and M. Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpcher Str. 77, 50937 Köln, Germany — [2]Institut Laue-Langevin, BP 156, 6 rue Jules Horowitz, 38042 Grenoble Cedex 9, France — [3]Institute for Material Research, Tohoku University, Katahira, Sendai 980-8577, Japan — [4]Hamburger Synchrotronstrahlungslabor HASYLAB at Deutsches Elektronen-Synchrotron, 22603 Hamburg, Germany

The role of electron-phonon coupling and its relevance to the pairing meachanism in high-temperature superconductivity is still a matter of controversy. The $(La,Sr)_2CuO_4$ (LSCO) system appears well suited for a study of the electron phonon coupling as the lattice dynamics is less complex than that of other cuprates. The strongest signatures of electron-phonon coupling are found in the longitudinal bond-stretching branches. In general these modes couple to charge fluctuations on the metal sites. In particular, the polarization patterns of modes propagating along the [100]-direction correspond to the distortions expected for the stripe ordering, which occurs in Nd-codoped LSCO and in $La_{1.88}Ba_{0.12}CuO_4$. We have searched for charge stripe order and studied the electron phonon coupling in the spin glass phase of LSCO ($x = 0.05$). Furthermore, the response of the electron phonon anomaly in LSCO ($x \approx 0.12$) on Zn- and Ni-doping was analysed.

TT 25.5 Wed 10:30 HSZ 304

Static and fluctuating stripe order in 1/8-doped LNSCO and LSCO — •Hsueh-Hung Wu[1,2], Marcel Buchholz[1], Christoph Trabant[1], Franziskus Heigl[3], Enrico Schierle[4], Matthias Cwik[1], Markus Braden[1], Liu-Hao Tjeng[1], and Christian Schüssler-Langeheine[1] — [1]II. Physikalisches Institut, Universitaet zu Koeln, Germany — [2]NSRRC, Hsinchu, Taiwan — [3]ALBA, Barcelona, Spain — [4]Helmholtz-Zentrum Berlin

We have studied the stripe order in $La_{1.475}Nd_{0.4}Sr_{0.125}CuO_4$ (LNSCO) and $La_{1.88}Sr_{0.12}CuO_4$ (LSCO) using resonant soft x-ray diffraction (RSXD). In both systems, a pronounced charge order (CO) peak was found at the oxygen K and copper $L_{2,3}$ edges. While for LNSCO, Nd stabilizes the static CO, no static CO has been found in LSCO [1]. In fact, earlier experiments from the isostructural nickelate system indicates that RSXD is suited to observe not only static, but also fluctuating order. This is particularly interesting for fluctuating CO, which is very difficult to probe with inelastic neutron diffraction. For LNSCO, the CO signal vanishes near the tetragonal to orthorhombic structural transition; in LSCO, the signal vanishes slightly above the critical temperature similar to what has been found for the spin order [2]. The resonance of the CO signal in both samples looks very similar at the O K edge, while some differences at the Cu $L_{2,3}$ edges are found. The spectroscopic interpretation of these findings will be discussed.

[1] M. Fujita *et al.*, Phys. Rev. Lett. **88**, 167008 (2002).
[2] H. Kirmura *et al.*, Phys. Rev. B **59**, 6517 (1999).

TT 25.6 Wed 10:45 HSZ 304

Interplay of charge stripe order with structural distortions: a high pressure x-ray study — •M. v. Zimmermann[1], M. Huecker[2], J.M. Tranquada[2], M. Debessai[3], J.S. Schilling[3], and G.D Gu[2] — [1]Hamburger Synchrotronstrahlungslabor HASYLAB at Deutsches Elektronen-Synchrotron, 22603 Hamburg, Germany — [2]Brookhaven National Laboratory, Upton, New York 11973, USA — [3]Dept. of Physics, Washington University, St. Louis, Missouri 63130, USA

The stability of charge stripe order in $La_{2-x}Ba_xCuO_4$ (LBCO) is still poorly understood. At x=1/8 LBCO exhibits a pronounced suppression of superconductivity and a static ordering of of spins and charge into a stripe pattern. At the same doping a structural transition from the usual orthorhombic phase (LTO) into the low temperature tetragonal phase (LTT) is observed. By the application of pressure the stability of the LTT and the LTO phase can be tuned and thus the influence of these structural distortion on the stripe order be studied. Using high energy x-ray diffraction the presence of charge stripes in a lattice without long range distortions could be found, indicating that electronic effects also contribute to the stablity if stripe order.

15 min. break

TT 25.7 Wed 11:15 HSZ 304

Electron-Phonon Interaction in Strongly Correlated Systems — •giorgio sangiovanni[1] and olle gunnarsson[2] — [1]Vienna University of Technology — [2]Max-Planck Institute - Stuttgart

Oxygen isotope effect on the low-energy dispersion kink has been re-

cently reported by Iwasawa et al. using high-resolution laser photoemission [1], suggesting a major role of the half-breathing oxygen phonon in high-temperature superconducting cuprates. The same phonon mode displays a huge anomaly approximately half-way to the zone boundary in the dispersion and in the width detected by inelastic neutron scattering [2]. In order to get a strong coupling to the half-breathing and other phonon modes in theoretical calculations electronic correlations turn out to be an essential ingredient.

[1] H. Iwasawa, *et al.*, Phys. Rev. Lett. **101**, 157005 (2008)
[2] D. Reznik, *et al.*, Nature **455**, E6 (2008)

TT 25.8 Wed 11:30 HSZ 304

Momentum dependence of the electron-phonon coupling, phonon-induced pairing interaction, and self-energy effects in $YBa_2Cu_3O_7$ within the local density approximation — •Dirk Manske[1], Rolf Heid[2], Roland Zeyher[1], and Klaus-Peter Bohnen[2] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [2]Forschungszentrum Karlsruhe, Germany

Using the local density approximation (LDA) and a realistic phonon spectrum we calculate the momentum and frequency dependence of the electron-phonon coupling in $YBa_2Cu_3O_7$ and determine its consequences for the phonon-induced pairing interaction and for the electronic self-energy in the normal state.

The phonon-induced interaction has a pronounced peak for large momentum transfers and the interband contributions between bonding and antibonding band are of the same magnitude as the intraband ones. The dimensionless coupling constant in the d-wave channel λ^d, relevant for superconductivity, is only 0.022, i.e., even about ten times smaller than the small value of the s-wave channel.

For electronic states at the Fermi energy, the maximum in the real part of the phonon-induced self-energy at low frequencies is about a factor 5 too small compared to the experiment, resulting in a very small and smooth change in the slope of the electronic dispersion [1].

These findings suggest that phonons are not the important low-energy excitations, and cannot produce well-pronounced kinks in $YBa_2Cu_3O_7$, at least, within LDA.

[1] R. Heid, K.-P. Bohnen, R. Zeyher, D. Manske, PRL **100**, 137001 (2008).

TT 25.9 Wed 11:45 HSZ 304

Theory of two-particle excitations and the magnetic susceptibility in high-T_c cuprate superconductors — •Sascha Brehm[1], Enrico Arrigoni[2], Markus Aichhorn[3], Maximilian Kiesel[1], and Werner Hanke[1] — [1]Institute for Theoretical Physics and Astrophysics, University of Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Institute of Theoretical Physics and Computational Physics, Graz University of Technology, Petersgasse 16, 8010 Graz, Austria — [3]Centre de Physique Théorique, École Polytechnique, 91128 Palaiseau Cedex, France

Two-particle (2-p) excitations such as spin and charge excitations play a key role in high-T_c cuprate superconductors (HTSC). On the basis of a parameter-free theory, which extends the Variational Cluster Approach (a recently developed embedded cluster method) to 2-p excitations, the magnetic excitations of HTSC are shown to be reproduced for a Hubbard model within the relevant strong-coupling regime [1]. In particular, the resonance mode in the underdoped regime, its intensity, "hour-glass"dispersion and doping dependence are in good overall agreement with experiments [1]. Combined with the earlier results for the phase diagram and one-particle excitations, such as the electron-hole asymmetry in the doping dependence of AF and SC phases [2] and the presence of a gap dichotomy of the nodal and antinodal SC gaps [3], a consistent picture emerges, which lends substantial support to Hubbard-model descriptions of high-T_c cuprate superconductivity.

[1] S. Brehm et *al.*, arXiv:0811.0552.
[2] M. Aichhorn et *al.*, Phys. Rev. B 75, 235117 (2006).
[3] M. Aichhorn et *al.*, Phys. Rev. Lett. 99, 257002 (2007).

TT 25.10 Wed 12:00 HSZ 304

Raman study of $La_{2-x}Sr_xCuO_4$: Evidence of universal electronic properties — •Bernhard Muschler[1], Wolfgang Prestel[1], Leonardo Tassini[1], Seiki Komiya[2], Yoichi Ando[2], Michael Lambacher[1], Andreas Erb[1], and Rudi Hackl[1] — [1]Walther Meissner Institute, Bavarian Academy of Sciences and Humanities, 85748 Garching — [2]CRIEPI, Komae, Tokyo 201-8511, Japan

We report results of electronic Raman scattering (ERS) experiments in $La_{2-x}Sr_xCuO_4$ single crystals in the doping range $0.02 \leq x \leq 0.30$. Due to the momentum resolution of ERS we are able to independently analyze the nodal and the antinodal carriers. We extract static carrier relaxation rates from the Raman spectra by applying an extended Drude analysis. For the nodal carriers we find doping independent scattering rates which trace the transport data measured on the same crystal. For the antinodal carriers we find an evolution of the relaxation rates with doping. The relaxation rates are isotropic for $x > 0.20$. In the range $0.16 \leq x \leq 0.20$ the carrier lifetimes become momentum dependent. Below optimal doping there is a peak superimposed on the usual response of the carriers which originates from charge ordering fluctuations. This peak is observed in the nodal and the antinodal response for $x \leq 0.05$ and $x \geq 0.05$, respectively. The temperature dependence indicates the existence of a quantum critical point at $x = 0.18$ which is related to a charge ordering instability.

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TT 25.11 Wed 12:15 HSZ 304

Comparison of ARPES and Raman spectra — •Wolfgang Prestel[1], Bernhard Muschler[1], Nathalie Munnikes[1], Michael Lambacher[1], Andreas Erb[1], Yoichi Ando[2], Shimpei Ono[3], Toshizo Fujita[2], Andrea Damascelli[4], Hiroshi Eisaki[5], Martin Greven[6], and Rudi Hackl[1] — [1]Walther-Meissner-Institut, 85748 Garching — [2]Osaka University, Osaka 567-0047, Japan — [3]CRIEPI, Komae, Tokyo 201-8511, Japan — [4]UBC, Vancouver, BC V6T 1Z4, Canada — [5]AIST, Tsukuba 305-8568, Japan — [6]Stanford University, Stanford, CA 94305, USA

Cuprate superconductors are strongly correlated metals. In the overdoped range the electrons can be described in terms of Landau quasiparticles. They manifest themselves as well defined peaks in the angle-resolved photoemission (ARPES) spectra. Using ARPES results we can quantitatively predict the normal state Raman spectra above a doping of $p \approx 0.21$. For $p < 0.21$ we find discrepancies between simulation and experiment in the B_{1g} channel becoming increasingly strong for decreasing p. At optimal doping we compare ARPES data and Raman measurements also in the superconducting state. Here we use an analytic expression which reproduces the ARPES data quantitatively in the entire Brillouin zone. Similarly as in the normal state, the B_{2g} spectra are well reproduced, while there are discrepancies in B_{1g} symmetry.

The project has been supported by the DFG under grant number Ha2071/3-4 via the Research Unit FOR538.

TT 25.12 Wed 12:30 HSZ 304

Two component dynamics of the superconducting order parameter revealed by time-resolved Raman scattering — •Ilka Mahns[1], R. Pelangi Saichu[1], Arne Goos[1], Stephan Binder[1], Patrick May[1], Stefan G. Singer[1], Benjamin Schulz[1], Andrivo Rusydi[1,2], Julia Unterhinninghofen[3], Dirk Manske[4], Prasenjit Guptasarma[5], Mark S. Williamsen[5], and Michael Ruebhausen[1] — [1]Institut fuer Angewandte Physik, Universitaet Hamburg, Germany. Center for Free Electron Laser Science (CFEL), Hamburg, Germany — [2]Department of Physics, NUS, Singapore — [3]Institut fuer Theoretische Physik, Universitaet Bremen, Germany — [4]Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, Germany — [5]Department of Physics, University of Wisconsin,USA

The nature of the interaction between holes leading to superconductivity is encoded in the properties of the superconducting order parameter. These properties are reflected by the energy and the time scales on which the order parameter reacts to an external perturbation. Here, we present unique results detecting the dynamics of the superconducting order parameter in Bi-2212 by employing a time-resolved pump-probe Raman experiment. We find two different coupling mechanisms that contribute equally to the relaxation of the pair breaking peak. A model that couples holes through phonons is able to reproduce only one part of the condensate dynamics, thus, outlining also the importance of hole-spin interactions.

TT 25.13 Wed 12:45 HSZ 304

Charge-Transfer Excitons In Underdoped $Ca_{2-x}Na_xCuO_2Cl_2$ — •R. Schuster[1], S. Pyon[2], M. Knupfer[1], J. Fink[1,3], M. Azuma[4], M. Takano[4], H. Takagi[2], and B. Büchner[1] — [1]IFW Dresden, Institute for Solid State Research, P.O. Box 270116, D-01171 Dresden, Germany — [2]Department of Advanced Materials Science, University of Tokyo, Kashiwa 277 8581, Japan — [3]BESSY GmbH, Albert-Einstein-Strasse 15, 12489 Berlin, Germany — [4]Inst. Chem. Res., Kyoto Univ., Uji, Kyoto-fu 611-0011, Japan

Employing electron energy-loss spectroscopy we show that small val-

ues of doping in the system $Ca_{2-x}Na_xCuO_2Cl_2$ strongly influence the formation and dynamics of charge-transfer excitons in the Cu-O plane. We find a remarkable redistribution of spectral weight between the two modes seen in the insulator yielding a single sharp feature for non-zero doping; accompanied by a strong suppression of the dispersion. Our data may provide evidence for a prominent role of the magnetic background on the dynamics of charge-transfer excitations in underdoped cuprates.