TT 33: Symposium: High-Temperature Superconductivity

Time: Thursday 14:00–19:10 Location: H 0104

Invited Talk TT 33.1 Thu 14:00 H 0104

Transport Evidence for Quantum Criticality in Electron-doped Cuprates — •Richard Greene — University of Maryland, College Park, USA

Over the past few years, strong evidence for quantum critical behavior in electron-doped cuprates has been observed in transport [1], optical conductivity [2], ARPES [3], and neutron scattering [4] experiments. More recent work on $Pr_{2-x}Ce_xCuO_4$ films, using high-field resistivity and Hall Effect up to 60 T [6], low temperature thermopower [5] in the normal state, and in-plane angular magnetoresistance (AMR) [7], are consistent with the view that a quantum phase transition occurs under the superconducting dome near x =0.16 doping. These measurements can be interpreted with a spin-density-wave induced reconstruction of the Fermi surface, which leads to both electron and hole-like pockets. In this talk, I will review some of this work and compare it to recent high-field transport experiments in hole-doped cuprates, where evidence of electron-like Fermi surface pockets has been found [8].

1) Dagan et al. PRL 92, 167001 (2004) ;
2) Zimmers et al. Europhys. Lett. 70, 225 (2005);
3) Matsui et al., PRB 75, 224514 (2007) and references therein;
4) Motoyama et al., Nature 445, 912 (2007) and references therein;
5) Li et al. PRB 75, 020506R (2007) ;
6) Li et al. PRL 99, 047003 (2007) ;
7) W. Yu et al. PRB 76, 020503R (2007) ;
8) LeBoeuf et al. Nature 450, 533 (2007)

TT 33.2 Thu 14:30 H 0104

Signatures of non-monotonic *d*-wave gap in electron-doped cuprates — •Ilya Eremin[1,2], Evelina Tsoncheva[3], and Andrey Chubukov[3] — [1]Max-Planck Institut für Physik komplexer Systeme, 01187 Dresden, Germany — [2]Institute für Mathematische und Theoretische Physik, TU-Braunschweig, D-38106 Braunschweig, Germany — [3]Department of Physics, University of Wisconsin, Madison, WI 53706, USA

We address the issue whether the data on optical conductivity and Raman scattering in electron-doped cuprates below T_c support the idea that the $d-$wave gap in these materials is non-monotonic along the Fermi surface. We calculate the conductivity and Raman intensity for elastic scattering, and find that a non-monotonic gap gives rise to several specific features in optical and Raman response functions. We argue that all these features are present in the experimental data on $Nd_{2-x}Ce_xCuO_4$ and $Pr_{2-x}Ce_xCuO_4$ compounds.

Invited Talk TT 33.3 Thu 14:45 H 0104

Superconductivity in the Hubbard model and the two gap energy scales in high-temperature superconductors — •Markus Aichhorn[1], Enrico Arrigoni[2], Michael Potthoff[3], Zhong Bing Huang[4], and Werner Hanke[1] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg — [2]Institut für Theoretische Physik und Computational Physics, Technische Universität Graz — [3]I. Institut für Theoretische Physik, Universität Hamburg — [4]Department of Physics, Hubei University, Wuhan, China

Quite after the discovery of high-temperature superconductivity in the cuprate compounds, it has been proposed that the essential physics of these materials is captured by the Hubbard model. Although this model is conceputally very simple, an exact solution is not known for more than one spatial dimension. Thus, approximate or numerical evaluations are needed for these quasi 2D materials. Our understanding of the ground-state properties of the 2D Hubbard model has improved a lot due to the development of the dynamical mean-field theory and its cluster extension. We will discuss recent results obtained by the variational cluster approach (VCA), focusing on the symmetry-broken phases at zero temperature. Besides the discussion of the competition between antiferromagnetism and d-wave superconductivity at low hole doping, we will focus on the doping evolution of the superconducting gap. We show that the Hubbard model is indeed able to describe the experimentally found two energy scales in the underdoped cuprates, and give a possible explanation of this feature in terms of a spin-fluctuation-mediated pairing mechanism.

15 min. break

TT 33.4 Thu 15:30 H 0104

Momentum-resolved electron-phonon coupling and self-energy effects in $YBa_2Cu_3O_7$: an LDA study — •Rolf Heid[1], Klaus-Peter Bohnen[1], Roland Zeyher[2], and Dirk Manske[2] — [1]Forschungszentrum Karlsruhe, Institut für Festkörperphysik — [2]Max-Planck-Institut für Festkörperforschung, Stuttgart

The observation of kinks in the electronic dispersion of high-T_c cuprates by angle resolved photoemission experiments has revived the discussion about the importance of electron-phonon interaction in the cuprates. Here we determine the effect of the electron-phonon coupling on the electronic self-energy in the normal state within the local-density approximation. Using a realistic phonon spectrum we determine the momentum and frequency dependence of $\alpha^2F(\mathbf{k},\omega)$ in $YBa_2Cu_3O_7$ for the bonding, antibonding, and chain band. We find that the maximum in the real part of the self-energy at low frequencies is about a factor 5 too small compared to the experiment. The renormalization factor $Z(\mathbf{k},\omega)$, which determines the change in the slope of the electronic dispersion due to the interaction, varies smoothly as a function of frequency and momentum. These findings show that, at least within the LDA, phonons cannot produce well-pronounced kinks in $YBa_2Cu_3O_7$.

TT 33.5 Thu 15:55 H 0104

The phonon buckling mode in $YBa_2Cu_3O_{6+x}$ measured by inelastic neutron scattering — •Markus Raichle[1], Dmitry Reznik[2], Mohammed Bakr[1], Vladimir Hinkov[1], Klaudia Hradil[3], Daniel Lamago[2], Clemens Ulrich[1], Markus Bröll[1], Philippe Bourges[2], Yvan Sidis[2], Chengtian Lin[1], and Bernhard Keimer[1] — [1]MPI für Festkörperforschung, Stuttgart, Germany — [2]Laboratoire Léon Brillouin, Paris, France — [3]Universität Göttingen, Göttingen, Germany

Cuk et al. [Phys. Rev. Lett. 93, 117003 (2004)] and Devereaux et al. [Phys. Rev. Lett. 93, 117004 (2004)] relate the antinoidal kink in ARPES measurements with the B1g phonon buckling mode. However, this assumption is controversial as this kink has also been related to the magnetic resonance mode by Kaminski et al. [Phys. Rev. Lett. 86, 1070 (2001)] and Kim et al. [Phys. Rev. Lett. 91, 167002 (2003)]. Until now inelastic neutron scattering measurements on this phonon mode on $YBa_2Cu_3O_{6+x}$ by Reznik et al. [Phys. Rev. Lett. 75, 2396 (1995)] has only been done on twinned samples for x=1. Here we present high resolution neutron measurements on the buckling mode on YBCO for x=0.6 and x=1.0. These measurements performed at Puma and 1T1 at Saclay have been made on fully detwinned samples. Thus we could show that this phonon mode performes an anisotropic superconductivity-induced interaction with a neighboring phonon mode. Hence these measurements enrich the experimental evidence for superconductivity induced phonon effects in high temperature superconductors.

TT 33.6 Thu 16:10 H 0104

d-wave stripes in cuprates: Valence bond order coexisting with nodal quasiparticles — •Matthias Vojta — Institut für Theoretische Physik, Universität Köln, 50937 Köln, Germany

We point out that unidirectional bond-centered charge-density-wave states in cuprates involve electronic order in both s- and d-wave channels, with non-local Coulomb repulsion suppressing the s-wave component. The resulting bond-charge-density wave, coexisting with superconductivity, is compatible with momentum-space features seen in recent photoemission and tunneling data and as well as in neutron-scattering measurements, once long-range order is destroyed by slow fluctuations or glassy disorder.

TT 33.7 Thu 16:35 H 0104

Charge order in $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$ studied by resonant soft X-ray diffraction — •J. Fink[1,2], E. Weschke[3], E. Schierle[3], J. Geck[4], H. Hawthorn[4], H. Widati[4], H.-H. Hu[5], H. Dürr[1], B. Büchner[2], and G. A. Sawatzky[4] — [1]BESSY, Albert-Einstein-Strasse 15, 12489 Berlin — [2]IFW Dresden — [3]Hahn-Meitner-Institut Berlin — [4]UBC Vancouver, Canada — [5]II. Physikalisches Institut, Universität Köln

Stripe-like phases in hole-doped cuprates, in which antiferromagnetic domains are separated by periodically spaced domain walls to which the charge carriers are segregated, are caused by a complex interplay between lattice defects and charge and spin degrees of freedom. In $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$ a stripe-like phase replaces almost the entire superconducting phase because in this system stripes are stabilized by the existence of a low-temperature tetragonal phase in a large concentration range. In order to directly prove the existence of charge ordering in these compounds we have used resonant soft X-ray scattering at the O1s and Cu2p edges. Long-range charge order exists at low temperatures and x close to 1/8. At higher temperatures and for x = 0.15 the coherence length is reduced due to fluctuations and/or a reduced order.

TT 33.8 Thu 16:50 H 0104

q-dependence of the giant bond-stretching phonon anomaly in the stripe compound $La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$ measured by IXS — •Daniel Lamago[1,2], Dmitry Reznik[2], T. Fukuda[3], K. Yamada[4], and A.Q.R. Baron[4] — [1]CEA Saclay, 91191 Gif Sur Yvette, France — [2]Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany — [3]Synchrotron Radiation Research Unit, Japan Atomic Energy Agency (Spring 8), Sayo, Hyogo 679-5148, Japan — [4]Materials Dynamics Laboratory, Harima RIKEN, 1-1-1 Kouto, Sayo, Hyogo, 679-5148 Japan

Inelastic x-ray scattering (IXS) was used to study the Cu-O bond-stretching vibrations in the static stripe phase compound $La_{1.48}Nd_{0.4}Sr_{0.12}CuO_4$. It was found that the intrinsic width in Q-space of the previously reported huge anomalous phonon softening and broadening is approximately 0.08 r.l.u. HWHM. A detailed comparison was also made to inelastic neutron scattering (INS) studies, which reported a two-peak lineshape with a "normal"and an "anomalous"phonon peaks. The "normal"branch in the neutron data seems to be mostly suppressed in the high resolution IXS data. Otherwise the agreement between the INS and the IXS was excellent.

TT 33.9 Thu 17:05 H 0104

Charge ordering phenomena and superconductivity in cuprates — •Leonardo Tassini, Bernhard Muschler, Wolfgang Prestel, Rudi Hackl, Michael Lambacher, and Andreas Erb — Walther-Meissner-Institut, 85748 Garching, Germany

The relationship between charge ordering phenomena and superconductivity was investigated with electronic Raman scattering in $La_{2-x}Sr_xCuO_4$ (LSCO) and $Y_{1-y}Ca_yBa_2Cu_3O_{6+x}$ (Y-123) single crystals. New low-energy excitations were found that are interpreted in terms of dynamical stripes. Below the onset point of superconductivity p_{sc1} the stripes are oriented along the diagonal of the CuO_2 planes for both LSCO and Y-123. The Raman data indicate that diagonal stripes compete with superconductivity. Apparently, stripes along the Cu − O direction lead to a relatively low-T_c such as in LSCO, while two-dimensional ordering such as observed by neutron scattering in Y-123 leads to high-T_c of the order of 100 K.

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15 min. break

TT 33.10 Thu 17:45 H 0104

Electronic liquid crystal state in a strongly underdoped high-temperature superconductor — •V. Hinkov[1], D. Haug[1], B. Fauque[2], Y. Sidis[2], P. Bourges[2], A. Ivanov[3], C. Bernhard[4], CT. Lin[1], and B. Keimer[1] — [1]MPI-FKF, Stuttgart — [2]LLB, Saclay, France — [3]ILL, Grenoble, France — [4]Univ. of Fribourg, Switzerland

Liquid crystals are states of matter without static crystalline order that break the rotational symmetry of free space while at least partially preserving its translational symmetry. Highly correlated electronic phases with symmetry properties analogous to those of conventional liquid crystals have been theoretically predicted (Kivelson et al., Nature 393, 550) and recently discovered in the layered bulk transition metal oxide $Sr_3Ru_2O_7$ (Borzi et al., Science 315, 214). In both cases, however, these phases are stable only at milli-Kelvin temperatures and in high magnetic fields, and have thus far only been probed by transport measurements. After briefly summarizing our work on $YBCO_{6.6}$ (Hinkov et al., Nature Physics 3, 780), we report the spontaneous onset of a strong one-dimensional, incommensurate modulation of the spin system in the underdoped high-temperature superconductor $YBa_2Cu_3O_{6.45}$ upon cooling below 150 K, while muon-spin-relaxation experiments on the same sample demonstrate that static magnetic order is absent down to temperatures of at least 2 K. The symmetry properties of the spin system thus match those of a nematic liquid crystal over a wide temperature range. Soft spin fluctuations are thus a microscopic route towards the formation of electronic nematic phases, which can coexist with high-T_c superconductivity.

TT 33.11 Thu 18:10 H 0104

ARPES of Bi-cuprates: Did we mix up apples and oranges? — •Lenart Dudy, Olaf Lübben, Beate Müller, Alica Krapf, Helmut Dwelk, Christoph Janowitz, and Recardo Manzke — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr.15, D-12489 Berlin, Germany

In the two decades of research on the pairing mechanism of the hole-doped high temperature superconductors, angular resolved photoemission (ARPES) has shown to be a good tool to study its microscopic origin [1]. But although two dimensional patterns in scanning tunneling microscopy(STM) have been discovered for a long time [2], the impact of these modulations on the photoemission signal is still widely ignored. Therefore we argue that features extracted out of photoemission experiments like the self energy and its temperature dependence have to be handled more critically. This will be demonstrated in context to an experimental motivated simple model [3], where the photoemission signal is decisively influenced by the modulations found by STM.

[1] A. Damascelli et al., Rev. Mod. Phys. 75, 473 (2003) and reference therein; M.R. Norman and C. Pepin, Rep. Prog. Phys. 66, 1547 (2003) and reference therein

[2] Ø. Fischer et al., Rev. Mod. Phys. 79, 353 (2007) and reference therein

[3] L. Dudy et al., Solid State Comm. 143, 422 (2007)

TT 33.12 Thu 18:25 H 0104

Effects of out-of-plane disorder on the superconductivity of $Bi_2Sr_{2-x}La_xCuO_{6+\delta}$ — •Jürgen Röhler[1], Christoph Trabant[1], Johanna Frielingsdorf[1], Rabia Djemour[1], Victor Martovitsky[2], Lenart Dudy[3], Helmut Dwelk[3], and Alica Krapf[3] — [1]Universität zu Köln, 50937 Köln — [2]Lebedev-Institute, 119991 Moscow — [3]Humboldt Universität zu Berlin, 12489 Berlin

The effects of out-of-plane substitutional order/disorder on cuprate superconductivity remains to a large extent an unresolved issue. We have investigated the connection between superconductivity and the lattice effects arising from the heterovalent doping of $Bi_2Sr_{2-x}La_xCuO_{6+\delta}$, $x = 0.8 - 0.1$. Decreasing lanthanum content tunes the compound through the entire underdoped and overdoped regimes. Cu-K and La-K EXAFS served as local structural probes, and single crystal x-ray diffraction for the determination of the basic unit cell, and the symmetry of the supercell. The oxygen atoms in the CuO_2 planes were found significantly disordered, dependent on doping, and to exhibit minimum disorder around $x_{opt} = 0.33$. But the degree of substitutional disorder in the out-of-plane La environment turned out independent on the concentration of the La dopants, the superstructure symmetry, and the crystal growth parameters, whereas T_c depends sensitively on them. No evidence was found for possible concentration dependent site changes of the La dopant from the nominal Sr to the Bi sites. We discuss the probably crucial role of the interstitial oxygen atoms for the superconducting properties of the $Bi_2Sr_{2-x}La_xCuO_{6+\delta}$ system.

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TT 33.13 Thu 18:40 H 0104

Indications on fluctuation origin of the recently observed giant Nernst effect in superconductors above T_c — •A.A. Varlamov — COHERENTIA-INFM, CNR, Rome, Italy

There are two types of fluctuation corrections: the first, like conductivity, have to be compared with the corresponding value of the normal state, the second, like fluctuation magnetization, reflect appearance of principally new quality and have to be compare with the anomalous diamagnetism of superconducting phase. I will show that the Nernst signal belongs to the effects of the second type. Both GL phenomenology and microscopic analysis indicate that Nernst effect, negligible in normal metal manifests itself by giant fluctuations along the line T_c(H).