TT 24: SC: Properties, Electronic Structure, Mechanisms

Time: Wednesday 14:00–18:45 Location: H19

TT 24.1 Wed 14:00 H19

Tight-binding parameterization of the O-doped high-temperature superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ — •Kateryna Foyevtsova[1], Hai Ping[2], Hem Kandpal[1], Harald Jeschke[1], Roser Valenti[1], and Peter Hirschfeld[2] — [1]Institut für Theoretische Physik, Goethe-Universität Frankfurt, 60438 Frankfurt am Main, Germany — [2]University of Florida, Gainesville, Florida 32611, USA

Recent scanning tunneling microscopy studies of several hole-doped high-T_c cuprate superconductors reveal a positive correlation between the position of a dopant atom and the size of local superconducting gap. These findings can be explained in the framework of spin exchange mediated pairing theories of superconductivity in cuprates, provided that in the parent compound certain modifications of local electronic structure occur due to a dopant, which has been so far neither proved nor disproved.

We present a Density Functional Theory study on oxygen-doped $Bi_2Sr_2CaCu_2O_{8+\delta}$ aimed at gaining insight into the dopant-induced variations of electronic structure of this high-T_c superconductor. In our study, we develop a method to characterize the $Bi_2Sr_2CaCu_2O_{8+\delta}$ bandstructure in terms of a single-band tight-binding (TB) Hamiltonian. We present three alternative TB models and critically discuss the achievements and drawbacks of the proposed approach. The discussion is supplemented by comparison of the spin susceptibilities and the pairing strengths calculated in the random-phase approximation from the derived TB models.

TT 24.2 Wed 14:15 H19

Superconducting Coherence Peak in the Electronic Excitations of a Single-Layer Bi2201 Cuprate Superconductor — •Jia Wei[1,2], Martin Aeschlimann[1], and Donglai Feng[2] — [1]Department of Physics, University of Kaiserslautern, Fachbereich Physik, Erwin Sch€oodinger Str. 46, 67663 Kaiserslautern, Germany — [2]1Department of Physics, Surface Physics Laboratory (National Key Laboratory) and Advanced Materials Laboratory, Fudan University, Shanghai 200433, P. R. China

Angle resolved photoemission spectroscopy study is reported on a high quality optimally doped Bi(La)2201 high-Tc superconductor. In the antinodal region with a maximal d-wave gap, the symbolic superconducting coherence peak, forming a so-called "peak-dip-hump" (PDH) structure, which has been widely observed in multi-CuO_2-layer cuprate superconductors, is unambiguously observed in a single-layer system. We have discovered the PDH in the antinodal region of the La-Bi2201. The 19 meV peak-dip separation seriously challenges models based on electron-phonon interactions. Meanwhile, this energy scale is much smaller than its counterparts in multi-layered compounds, but correlates with the energy scales of spin excitations in single layer cuprates. Our data provide a critical piece to the global picture of the bosonic mode and gap in cuprates, which would help to eventually resolve controversial issues and uncover the "glue" of high-T_c superconductivity.

TT 24.3 Wed 14:30 H19

Polarized XAS on single layer Bi-cuprates: Probing the ground state beyond the conventional $d_{x^2-y^2}$ picture — •Beate Müller, Ahmad Ariffin, Rüdiger Mitdank, Lenart Dudy, Peter Hlawenka, Alica Krapf, Helmut Dwelk, Christoph Janowitz, and Recardo Manzke — Institut für Physik, Humboldt Universität Berlin, Newtonstr. 15, 12489 Berlin

CuL_3 and OK XAS studies on the single layer Bi-cuprate (Pb,Bi)2201 with different combinations of La and Pb substitutions and thus varied doping levels are presented. A polarization dependence within the CuO_2 plane was found which should not exist following the assumptions of a one-band model based on $d_{x^2-y^2}$ symmetric Zhang-Rice singlets. This dependence on the azimuthal angle modulates spectral features believed to be related to the Zhang-Rice singlet. Its characteristics over angle reveals signatures that move beyond the expected $d_{x^2-y^2}$ symmetry and point towards the inclusion of axial orbitals as proposed by Anderson et al. [J. Phys. Chem. Solids 56, 1573 (1995)] and Pavarini et al. [Phys. Rev. Lett. 87, 047003 (2001)].

TT 24.4 Wed 14:45 H19

High-Temperature optical behavior of Bi-based cuprates — •Georg Rohringer[1], Alessandro Toschi[1], Daniele Nicoletti[2], Paolo Calvani[2], Stefano Lupi[2], Massimo Capone[3], Giorgio Sangiovanni[1], and Karsten Held[1] — [1]Institute of Solid State Physics, Vienna University of Technology — [2]CNR-INFM Coeherentia and Department of Physics, University of Rome "La Sapienza" — [3]CRS SMC, CNR-INFM and Department of Physics, University of Rome "La Sapienza"

The optical conductivity $\sigma(\omega)$ and the optical spectral weight W provide important information about the physical properties of strongly correlated systems[1,2]. This is the case for cuprates, where DMFT calculations have shown the important role of the quasiparticle renormalization factor Z, which manifests itself in a strong temperature (T) dependence of W at low T. We analyze here new experimental results for the normal phase of two Bi-based cuprates up to 500K. The comparison between our DMFT calculations and the experimental data for W allows for a full understanding of the observed deviation ($\propto T^4$) from the low-temperature T^2 behavior in the framework of a Sommerfeld expansion with strongly renormalized coefficients[3].

[1] L. Baldassarre et al., Phys.Rev. B **77**, 113107 (2008)
[2] A. Toschi et al., Phys.Rev.Lett. **95**, 097002 (2005)
[3] D. Nicoletti, O. Limaj, P. Calvani, G. Rohringer, et al. in preparation.

TT 24.5 Wed 15:00 H19

Importance of local correlations for the order parameter of high-T_c superconductors — •Matthias Balzer and Michael Potthoff — I. Institut für Theoretische Physik, Universität Hamburg, Germany

Using an extension of the variational cluster approximation (VCA), the relevance of bath degrees of freedom in a cluster-embedding approach for the size of the d-wave superconducting order parameter is studied within the hole- and electron-doped two-dimensional Hubbard model at zero temperature. We discuss results obtained for a reference system consisting of a plaquette of four correlated and four bath sites in addition and compare with results obtained via VCA for the plain plaquette without bath sites on the one hand and with results from previous cellular (plaquette) dynamical mean-field calculations on the other. It is shown that local, i.e. temporal, correlations are essential: Including a single bath degree of freedom considerably decreases the order parameter and provides a substantial gain of binding energy. Bath sites are also seen to partially compensate for the artificial breaking of translational symmetry introduced by the real-space quantum cluster approach.

15 min. break

Invited Talk TT 24.6 Wed 15:30 H19

Fermi Surface Evolution in an Electron-Doped Cuprate Superconductor Revealed by High-Field Magnetotransport — •Mark Kartsovnik — Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany

Establishing the Fermi surface topology and its dependence on carrier concentration is fundamentally important for understanding the role of electronic correlations and resulting ordering instabilities in superconducting paring in high-T_c cuprates. I will present recent experiments on magnetic quantum oscillations in the electron-doped cuprate $Nd_{2-x}Ce_xCuO_4$ providing direct evidence for a well-defined continuous Fermi surface and its evolution with doping level. Most interestingly, the Fermi surface is found to be reconstructed, most likely due to a magnetic ordering which occurs at a critical doping level significantly exceeding the optimal doping. Besides quantum oscillations, we have found semiclassical angle-dependent magnetoresistance oscillations (AMRO) which are directly related to the geometry of the underlying Fermi surface. The analysis of the AMRO in combination with the Shubnikov-de Haas data shows that a superlattice potential survives over the entire superconducting doping range. This suggests an intimate relation between magnetic ordering and superconductivity.

The work was done in cooperation with T. Helm, W. Biberacher, M. Bartkowiak, I. Sheikin, M. Lambacher, A. Erb, N. Bittner, J. Wosnitza, and R. Gross and supported by the DFG via Research Unit 538 and EuroMagNET II.

TT 24.7 Wed 16:00 H19

Angle-dependent interlayer magnetoresistance in the normal state of the electron-doped cuprate $Nd_{1-x}Ce_xCuO_4$ — •Toni Helm[1], Mark Kartsovnik[1], Pavel Grigoriev[2], Michael Lambacher[1], Andreas Erb[1], Ilya Sheikin[3], and Rudolf Gross[1] — [1]Walther-Meissner-Institit, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]L.D. Landau Institute for Theoretical Physics, Russian Ac. Sci., Chernogolovka, Russia — [3]Grenoble High Magnetic Field Laboratory, Grenoble, France

We report on systematic studies of the normal-state *c*-axis magnetoresistance of high quality single crystals of $Nd_{2-x}Ce_xCuO_4$ as a function of magnetic field orientation, performed for a broad range of Ce concentrations. In underdoped compounds, the major effect of magnetic field comes from coupling to spins in a magnetically ordered system. Notably, the spin-dependent magnetotransport prevails even for superconducting compositions, up to the optimal doping level. In the overdoped regime, the conventional orbital coupling of charge carriers to a magnetic field becomes dominant. Most interestingly, overdoped samples exhibit features characteristic of the so-called angle-dependent magnetoresistance oscillations (AMRO). We analyze the data using the semiclassical kinetic model and discuss the results in terms of the geometry of the Fermi surface responsible for the AMRO.

The work was supported by the DFG via Research Unit 538 and EuroMagNET II under the EU contract.

TT 24.8 Wed 16:15 H19

Superconducting fluctuation regime in $HgBa_2CuO_{4+\delta}$ revealed by microwave measurements — •Neven Barišić[1,3], Mihael S. Grbić[2], Antonije Dulčić[2], Yuan Li[3], Xudong Zhao[3], Guichuan Yu[3], Martin Dressel[1], Martin Greven[3,4], and Miroslav Požek[2] — [1]1. Physikalisches Institut, Universität Stuttgart, D-70550 Stuttgart, Germany — [2]Department of Physics, Faculty of Science, University of Zagreb, P.O. Box 331, HR-10002 Zagreb, Croatia — [3]Department of Physics, Stanford University, Stanford, California 94305, USA — [4]School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455, USA

Superconducting (SC) fluctuations belong to fundamental properties of high-T_c superconductors. Although studied by various experimental techniques the highest temperature at which the superconducting fluctuations can be observed, is not yet unambiguously determined. Thus, an alternative experimental verification of the SC fluctuation regime is desirable. We are proposing a novel approach to microwave conductivity measurements to elucidate the phase diagram of high- T_c. Measurement are performed on a model high-T_c material: $HgBa_2CuO_{4+\delta}$. From a set of the single c-axis data for a sample close to optimal doping we can clearly discern the opening of the pseudogap at T*=185 (15) K, the appearance of the superconducting fluctuations at a much lower temperature T'=105 (2) K, and the full transition to the superconducting state at the critical temperature T_c=94.3 K. Thus, with the presently acquired high sensitivity we establish that the superconducting fluctuations extend only to about 10 K above T_c.

TT 24.9 Wed 16:30 H19

The magnetic resonance mode in high-temperature superconductors — •Klaus W. Becker[1] and Steffen Sykora[1,2] — [1]Institut für Theoretische Physik, Technische Universität Dresden, Germany — [2]Department of Physics and Astronomy, Rutgers University, USA .

The origin of the magnetic resonance mode in cuprates, measured by inelastic neutron scattering, is still subject of controversy. In this talk, we investigate the resonance mode on the basis of the t-J model using a microscopic renormalization approach which is called projector based renormalization method (PRM). Thereby, the strong correlations are strictly obeyed. The approach was applied to the cuprates before in order to explain ARPES experiments in the pseudogap and in the superconducting region. The method also allows to evaluate the inelastic neutron scattering in the superconducting state of the cuprates. The theoretical results turn out to be in perfect agreement with the experimental findings.

TT 24.10 Wed 16:45 H19

Microscopic approach to high-temperature superconductors: Superconducting phase — •Steffen Sykora[1,2] and Klaus W. Becker[1] — [1]Institut für Theoretische Physik, Technische Universität Dresden, Germany — [2]Department of Physics and Astronomy, Rutgers University, USA

An understanding of the superconducting pairing mechanism of the high-temperature superconductors leading to an unprecedented high transition temperature T_c is still lacking. Starting from the *t*-*J* model, in this talk we present a microscopic approach to investigate physical properties of the superconducting phase in the framework of a novel renormalization scheme called PRM. This approach is based on a stepwise elimination of high-energy transitions using unitary transformations. We find a renormalized 'free' Hamiltonian for correlated electrons for the superconducting phase. Our microscopic approach allows us to explain the experimental findings in the underdoped as well as in the optimal hole doping regime. Our results turn out to be in good agreement with experiment: The superconducting order parameter shows *d*-wave symmetry with a coherence length of a few lattice constants. In good agreement with experiments, we find no superconducting solutions for very small hole doping. Furthermore, we calculate the ARPES spectral function along the Fermi surface. The spectra display peak-like structures which are caused alone by coherent excitations in a small range around the Fermi energy.

15 min. break

TT 24.11 Wed 17:15 H19

Plasmons and interband transitions of $Sr_{14-x}Ca_xCu_{24}O_{41}$ investigated by electron energy-loss spectroscopy — •Friedrich Roth, Martin Knupfer, Christian Hess, and Bernd Büchner — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Electron energy-loss spectroscopy has been used to investigate the loss-function between 0 and 70 eV of singel-crystalline $Sr_{14-x}Ca_xCu_{24}O_{41}$, composed of two-leg Cu_2O_3 ladders and edge-sharing CuO_2 chains, with various compositions. We found significant exitations in the low-energy range which are different for momentum transfer q parallel to the **a**- and **c**-axes. Comparison with reflectivity data from literature [1] shows a good agreement with our data. Also the disperions of a charge-carrier plasmon like in $Bi_2Sr_2CaCu_2O_8$ [2] was obeserved for $Sr_3Ca_{11}Cu_{24}O_{41}$.

[1] Osafune, T. et al., Phys. Rev. Lett. **78** 1980 (1997)
[2] Nücker, N. et al., Phys. Rev. B **39** 12379 (1989)

TT 24.12 Wed 17:30 H19

Optical conductivity of $LuNi_2B_2C$ in the terahertz range — •T. Fischer[1], A. V. Pronin[1], J. Wosnitza[1], T. Niemeier[2], and B. Holzapfel[2] — [1]Hochfeld-Magnetlabor Dresden (HLD), FZ Dresden-Rossendorf, 01314 Dresden, Germany — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung, 01171 Dresden, Germany

Using a backward-wave-oscillator-based setup in a Mach-Zehnder interferometer arrangement, we have measured the temperature- and frequency-dependent transmission and phase-shift spectra of $LuNi_2B_2C$ films on MgO substrates in the range 200 GHz - 1.4 THz. From the measured spectra, we have directly calculated the complex optical conductivity. We observe a clear signature of the superconducting energy gap in the spectra. In the talk, a comparison of the experimentally obtained spectra with theoretical predictions for a multi-band superconductor will be given.

TT 24.13 Wed 17:45 H19

Low temperature disorder of the stripe phase in layered nickelates — Christoph Trabant[1], Marcel Buchholz[1], Chun-Fu Chang[1], Ralf Feyerherm[2], Enrico Schierle[2], Esther Dudzik[2], Alexander Komarek[1], Agung Nugroho[3], Mohammed Benomar[1], Liu Hao Tjeng[1,4], Markus Braden[1], and •Christian Schüssler-Langeheine[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Helmholtz-Zentrum Berlin — [3]Institut Teknologi Bandung — [4]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden

In hole-doped layered nickelates and cuprates a collective order of charge and spin degrees of freedom is found, the so-called stripe phase. The holes arrange in lines, which act as domain walls for the antiferromagnetic order on the hole-poor sites. This order is formed upon cooling with a gradual increase of the correlation length. Remarkably the correlation length goes through a maximum and decreases again upon further cooling: The stripe order breaks apart at low temperatures. Generally not observed in neutron experiments, this effect has been predicted by theory as a consequence of competition between Coulomb repulsion and lattice potential. Also the effect of static disorder has been discussed. We present a systematic study of low-temperature disorder in doped nickelates using resonant diffraction in the conventional and soft x-ray range. We find that this effect depends mainly on the

total doping level and affects spin order and charge order in a similar way. The influence of static disorder is found to be small. Funded by the DFG through SFB 608 and by the BMBF project 05KS7PK1.

TT 24.14 Wed 18:00 H19

Origin of the nondispersive wavevector component at $\vec{q} = (3/4, 0)$ in the electronic structure of cuprate superconductors — •Jürgen Röhler — Universität zu Köln, 50937 Köln

A direct spectroscopic fingerprint of phase-incoherent precursor superconductivity in cuprates was recently obtained by spectroscopic imaging spectroscopy uncovering up to $T = 1.5\ T_c$ dispersive Bogoliubov quasiparticle excitations ($\pm E < 35$ meV) which coexist with true nondispersive and locally symmetry breaking excitations at the pseudogap energy scale ($\pm E \simeq 120$ meV) [1]. While the low-energy excitations are homogenously distributed in r-space, the high-energy excitations appear as static domains (width $4a$) scattered in random orientation on the xy-plane, but along no preferred Cu-O direction. This "glassy" component of the electronic structure is in conflict with "stripes" flowing preferrentially in one Cu-O direction. The $4a$ wide O-Cu-O-Cu-O-Cu-O-Cu-O domains exhibit an internal $3a$ structure by dominant charge contrast maxima at the central O site and the two outmost Cu sites. We analyze the corresponding wavevector components at $\vec{q} = (3/4, 0); (0, 3/4)$ as a signature of bond centered quartets of Zhang-Rice hole singlets forming pseudomoleculss with a characteristic length of $3a$ [2]. The internally antiferromagnetic $3a$ pseudomolecules may act as bosonic pairing centers exchanging resonantly paired quasiparticles with the dispersive low-energy sector of the superconducting condensate.

[1] J. Lee et al., Science **325** (2009), 1099.
[2] J. Röhler, Physica C**460-62** (2007), 374.

TT 24.15 Wed 18:15 H19

Ferromagnetism and d-wave superconductivity in the 2D Hubbard model — Carsten Honerkamp[1], •Christoph Husemann[2], Jutta Ortloff[3], and Manfred Salmhofer[2] — [1]Institut für Theoretische Physik C, RWTH Aachen, Germany — [2]Institut für Theoretische Physik, Universität Heidelberg, Germany — [3]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Germany

By using the functional renormalization group we compute detailed momentum dependencies of the scale-dependent interaction vertex of the 2D (t,t')-Hubbard model. Compared to previous studies we improve accuracy by separating dominant parts from a remainder term. The former explicitly describe, for example, the interaction of Cooper pairs or spin operators. Applying the method to the repulsive Hubbard model we find d-wave superconductivity or ferromagnetism for larger next-to-nearest neighbor hopping amplitude |t'| at Van Hove Filling. Both ordering tendencies strongly compete with each other.

TT 24.16 Wed 18:30 H19

Conserving T-matrix theory of superconductivity — •Klaus Morawetz[1,2], Pavel Lipavský[3,4], Bretislav Šopík[4], and Michael Männel[5] — [1]University of Applied Science Münster, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — [2]International Center for Condensed Matter Physics, Universidade de Brasília, 70904-910, Brasília-DF, 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]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany

Any many-body approximation corrected for unphysical repeated collisions in a given condensation channel is shown to provide the same set of equations as they appear by using anomalous propagators. The ad-hoc assumption in the latter theory about non-conservation of particle numbers can be released. In this way the widespread used anomalous propagator approach is given another physical interpretation. A generalized Soven equation follows which improves any approximation in the same way as the coherent potential approximation (CPA) improves the averaged T-matrix for impurity scattering. A selfconsistent T-matrix theory of many-Fermion systems is proposed. In the normal state the theory agrees with the Galitskii-Feynmann approximation, in the superconducting state it has the form of the renormalized Kadanoff-Martin approximation. The two-particle propagator satisfies the Baym-Kadanoff symmetry condition which guarantees that the theory conserves the number of particles, momentum and energy.