TT 42: Superconductivity: Fabrication, Properties, Electronic Structure

Time: Thursday 15:00–18:00 Location: H 3005

TT 42.1 Thu 15:00 H 3005

Angular-dependent specific heat of the fully organic superconductor β''-$(ET)_2SF_5CH_2CF_2SO_3$ - evidence for an FFLO phase — •Rico Beyer[1], J.A. Schlueter[2], and J. Wosnitza[1] — [1]Hochfeld-Magnetlabor (HLD), Forschungszentrum Dresden- Rossendorf (FZD), Dresden, Germany — [2]Materials Science Division, Argonne National Laboratory, Argonne, USA

Since 1964 predicted, there is no clear-cut experimental proof of the existence of a field-induced superconducting state with finite center of mass momentum ($\mathbf{q} \neq 0$) [1]. In 2007, Lortz *et al.* reported thermodynamic evidence for a FFLO state in κ-$(ET)_2Cu(NCS)_2$ [2], where ET stands for bisethylenedithio-tetrathiafulvalene. They found an emerging sharp double-peak structure in the specific heat, indicating first-order phase transitions at high magnetic fields applied parallel to the superconducting ET layers. Expecting similar novel results for β''-$(ET)_2SF_5CH_2CF_2SO_3$, we performed high-resolution specific-heat measurements for different orientations with very fine steps around perfect parallel alignment. In conclusion, we found an upturn in the field-temperature phase diagram of the superconducting phase beyond the Pauli-Clogston limit and we could observe a double-peak structure above 9,4 Tesla but only by tilting the field 0,2 degree out of the ET sheets. Part of this work has been supported by EuroMagNET, EU contract 228043.

[1] P. Fulde and R.A. Ferrel, Phys. Rev. **135**, A550 (1964); A.I. Larkin and Y.N. Ovchinnikov, Zh. Eksp. Teor. Fiz. **47**, 1136 (1964)
[2] R. Lortz *et al.*, Phys. Rev. Lett. **99**, 187002 (2007)

TT 42.2 Thu 15:15 H 3005

Low-temperature transport in ultra-thin tungsten films — •Olivio Chiatti[1,2], Christopher Nash[2], and Paul Warburton[2] — [1]Neue Materialien, Institut f. Physik, Humboldt-Univ. zu Berlin, D-10099 Berlin — [2]London Centre for Nanotechnology, University College London, 17-19 Gordon Street, London, WC1H 0AH, UK

Tungsten-containing films, fabricated by focused-ion-beam-induced chemical vapour deposition, are known to have an enhanced superconducting transition temperature compared to bulk tungsten [1], and have been investigated previously for film thickness down to 25 nm [2]. In this work, by using ion-beam doses below 50 pC/μm^2 on a substrate of amorphous silicon, we have grown continuous films with thickness below 20 nm. The electron transport properties were investigated at temperatures down to 350 mK and in magnetic fields up to 3 T, parallel and perpendicular to the films. The films in this work are closer to the limit of two-dimensional systems and are superconducting at low temperatures. Magnetoresistance measurements yield upper critical fields of the order of 1 T, and the resulting coherence length is smaller than the film thickness.

[1] Sadki et al., Appl. Phys. Lett. **85**, 6206 (2004)
[2] Li et al., J. Appl. Phys. **104**, 093913 (2008); Li et al., IEEE Trans. Appl. Superc. **19**, 2819 (2009)

TT 42.3 Thu 15:30 H 3005

Vibrational and Thermal Properties of ZnX (X=S, Se, Te): Density Functional Theory versus Experiment — •Reinhard K. Kremer[1], Manuel Cardona[1], Robert Lauck[1], Gisela Siegle[1], Aldo H. Romero[2], and Alexander Schindler[3] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [2]Departamento de Materiales, Unidad Querétaro, CINVESTAV, Querétaro 76230, Mexico — [3]NETZSCH-Gerätebau GmbH, Wittelsbacherstrasse 42, D-95100 Selb, Germany

We calculated the phonon dispersion relations of ZnX (X=S, Se, Te) employing up-to-date *ab initio* codes. The dispersion relations have been used to evaluate the temperature dependence of the respective specific heats of crystals with varied isotopic compositions. These results are compared with measurements performed on crystals down to 2 K. The calculated and measured data are generally in excellent agreement. Trends in the phonon dispersion relations and the corresponding densities of states for the zinc chalcogenide series of zincblende type materials are discussed.

TT 42.4 Thu 15:45 H 3005

Ultrafast Phonon Hardening in Copper after Femtosecond Laser Excitation — •Fairoja Cheenicode Kabeer, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretical Physics, University Kassel, Heinrich-Plett-Str. 40, Kassel, Germany

When a femtosecond laser pulse interacts with a material it produces hot electrons, which can lead to changes in the interatomic potential. As a consequence, the lattice becomes unstable and forces appear on the atoms, driving many interesting ultrafast structural phenomena involving lattice vibrations. In this work we compute the dynamical matrix of copper before and after femtosecond laser excitation. For all phonon modes we find hardening as a function of the electronic temperature in the laser-excited state, which is opposite to the behavior of most materials, which soften when electrons are excited. We use this finding to study the possibility to squeeze the lattice vibrations in copper at low temperatures below the zero point motion.

TT 42.5 Thu 16:00 H 3005

A combined experimental and theoretical de Haas-van Alphen study on $PrPt_4Ge_{12}$ — V. Petzold[1], •B. Bergk[2,3], R. Gumeniuk[1], O. Ignatchik[2], A. Polyakov[2], K. Götze[2], A. Leithe-Jasper[1], W. Schnelle[1], M. Nicklas[1], J. Wosnitza[2], J. Grin[1], and H. Rosner[1] — [1]Max Planck Institute for Chemical Physics of Solids, D-01187 Dresden, Germany — [2]Hochfeld-Magnetlabor Dresden – Helmholtz-Zentrum Dresden-Rossendorf, D-01314 Dresden, Germany — [3]Technische Universität Dresden, Institute of Materials Science, D-01069 Dresden, Germany

The skutterudite $PrPt_4Ge_{12}$ superconducts at a surprisingly high temperature of $T_c \approx 8$ K [1]. Furthermore, a remarkably strong coupling [1], a gap function with point-like nodes [2], the exclusion of heavy fermions as an explanation [2], or the breaking of time-reversal symmetry [3] could not yet be arranged in a unified picture.

In this study, we combine band structure calculations and experiments to elucidate the electronic structure of $PrPt_4Ge_{12}$. We treat the strongly correlated 4f electrons of Pr in various approximations. Their reliability is tested by comparing with de Haas-van Alphen (dHvA) measurements on $PrPt_4Ge_{12}$ single crystals.

With the dHvA data-based strategy, introduced in [4], we estimate which parts of the complex Fermi surface are affected by the strong coupling established in the literature [1] .

[1] Gumeniuk et al., PRL **100** (2008) 017002,
[2] Maisuradze et al., PRL **103** (2009) 147002,
[3] Maisuradze et al., PRB **82** (2010) 024524,
[4] Bergk et al., PRL **100** (2008) 257004

TT 42.6 Thu 16:15 H 3005

Electronic structure of doped hydrocarbon superconductors — •Friedrich Roth[1], Benjamin Mahns[1], Matteo Gatti[2], Pierluigi Cudazzo[2], Bernd Büchner[1], Angel Rubio[2], and Martin Knupfer[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Nano-Bio Spectroscopy group and ETSF Scientific Development Centre, Dpto. Física de Materiales, Universidad del País Vasco, Av. Tolosa 72, E-20018 San Sebastián, Spain

We performed electron energy-loss spectroscopy studies in transmission in order to get a deeper insight into the electronic structure of the potassium intercalated recently discovered aromatic hydrocarbon superconductors, such as picene or coronene. A comparison of the loss function of the undoped and doped compound shows the appearance of a new peak in the case of picene and several new peaks in the case of coronene in the optical gap. For picene we find a remarkable negative plasmon dispersion and a dramatic increase for the value of the background dielectric constant upon doping.

15 min. break.

TT 42.7 Thu 16:45 H 3005

Density functional theory study of alkali doped picene — •Milan Tomić, Hunpyo Lee, Roser Valentí, and Harald Jeschke — Institut für Theoretische Physik, Goethe-Universität, Frankfurt am Main, Germany

We have employed density functional theory methods to determine the equilibrium structures of $A_x$picene where A = Na, K, Rb, Cs and x = 1, 2, 3. We have also considered x=4 case in the light of possibility of mixed phase existence. We have found that alkali doping with one, two and three alkali ions per picene molecule leads to subsequent filling of

the LUMO and LUMO+1derived bands of picne, leading to quarter, half and three quarter filled systems. We have analysed the electronic structures using tight binding methods to derive the kinetic energy part of the underlying Hubbard Hamiltonian. As the interaction strength U on the picene molecules is expected to be large compared to the bandwidth, we have also employed manybody methods on the resulting Hamiltonian. We have also compared our results to photoemission experiments.

TT 42.8 Thu 17:00 H 3005

Non-metallicity in potassium-doped picene films — •Andreas Ruff[1], Milan Tomic[2], Hunpyo Lee[2], Harald O. Jeschke[2], Roser Valentí[2], Michael Sing[1], and Ralph Claessen[1] — [1]Experimentelle Physik 4, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]Institut für Theoretische Physik, Goethe-Universität Frankfurt, 60438 Frankfurt am Main, Germany

We have performed a comparative study of the electronic structure of the potassium-doped organic semiconductor picene ($K_x$picene) using photoemission and density-functional calculations.

Theoretically we have investigated compounds of $K_x$picene with integer $x = 1, 2, 3$ to clarify the atomic positions of the alkali metal dopants and the resulting bandstructure. Experimentally, we recorded a series of photoemission spectra with doping concentrations in the range of $x = 0...3$. While the *ab initio* electronic structure calculations reveal metallic behavior for K_1picene and K_3picene and semiconducting properties for K_2picene, the system remains insulating for all doping concentrations x from the spectroscopic view.

We discuss this discrepancy in terms of possible strong electron correlation effects and/or phonons as well as the occurrence of chemical phase separation in our samples.

TT 42.9 Thu 17:15 H 3005

Energy-Gap Dynamics of a Superconductor NbN Studied by Time-Resolved Terahertz Spectroscopy — •Matthias Beck[1], Paul Leiderer[1], Viktor V. Kabanov[2], Gregory Gol'tsman[3], Manfred Helm[4], and Jure Demsar[1,2] — [1]Dept. of Physics and Center for Appl. Photonics, Univ. of Konstanz — [2]Zukunftskolleg, Univ. of Konstanz, — [3]Moscow State Ped. Univ., Moscow — [4]Helmholtz-Zentr., Dresden-Rossendorf

Using time-resolved terahertz (THz) spectroscopy we performed direct studies of the photoinduced suppression and recovery of the SC gap in a conventional SC NbN. Both processes are found to be strongly temperature and excitation density dependent. The analysis of the data with the established phenomenological Rothwarf-Taylor model enabled us to determine the important microscopic constants: the Cooper pair-breaking rate via phonon absorption and the bare quasiparticle recombination rate. From the latter we were able to extract the dimensionless electron-phonon coupling constant, $\lambda = 1.1 \pm 0.1$, in excellent agreement with theoretical estimates. The technique also allowed us to determine the absorbed energy required to suppress SC, which in NbN equals the thermodynamic condensation energy (in cuprates the two differ by an order of magnitude). Finally, we present the first studies of dynamics following resonant excitation with intense narrow band THz pulses tuned to above and below the superconducting gap. These suggest an additional process, particularly pronounced near T_c, that could be attributed to amplification of SC via effective quasiparticle cooling.

TT 42.10 Thu 17:30 H 3005

Correlation Effects in the Double Photoemission of Pb(111) — •Robert Wallauer, Stefan Voss, Achim Czasch, Lutz Foucar, Till Jahnke, Horst Schmidt-Böcking, and Reinhard Dörner — Institut für Kernphysik, Universität Frankfurt

The investigation of two electrons emitted by a single photon is particulary sensitive to correlation effects, since their coincident emission is forbidden in the absence of any interaction between them. In order to study this process, we setup an experiment in which we measure two electrons in coincidence and can calculate their complete momentum.

We measured a Pb single crystal in superconducting and normal state at Photon energies between 20 and 40 eV. The emission of Cooperpairs has been predicted for this process. Despite of highly improved pulse analysis tools, it could not be identified so far. For photon energies above 25 eV the DPE current is dominated by Auger-processes involving the 5d(5/2) and 5d(3/2) core levels. Both, Auger- and Photoelectron are detected in coincidence and the interaction between them can be studied energy- and angular-resolved.

TT 42.11 Thu 17:45 H 3005

Incorporation of self-organised gold nano crystals in $YBa_2Cu_3O_{7-\delta}$ thin films: Modification of superconducting properties — •Christian Katzer[1], Peter Michalowski[1], Markus Westerhausen[1], Stefanie Koch[1], Frank Schmidl[1], Sebastian Treiber[2], Joachim Albrecht[3], and Paul Seidel[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Helmholtzweg 5, 07743 Jena, Deutschland — [2]Max-Planck-Institut für Intelligente Systeme, Heisenbergstraße 3, 70569 Stuttgart, Deutschland — [3]Hochschule Aalen, Beethovenstraße 1, 73430 Aalen, Deutschland

Using pulsed laser deposition we are able to fabricate and examine Yttrium-Barium-Copper-Oxide (YBCO) thin films of high quality. A particular point of interest thereby is the influence of a pre-deposited gold layer with a well-defined film thickness. During the growth of the YBCO thin film the intermediate gold layer self assembles into crystalline nano particles, which modify the growth conditions and hence the physical properties of the growing YBCO. We report on the modification of structural and superconducting properties of our YBCO thin films (such as rocking curve widths, critical temperature T_c and critical current density j_c) comparing conventional to Au added YBCO. The temperature dependence of the critical current density thereby was determined using transport measurements as well as magneto-optical measurements [1]. Furthermore investigations of the flux noise of our gold modified YBCO films will be presented.

[1] C. Katzer et al., Europhys. Lett. **95** (2011), 68005