TT 14: Superconductivity: Non-Cuprate Non-Ferropnictide Superconductors

Time: Tuesday 9:30–12:15 Location: HSZ 105

TT 14.1 Tue 9:30 HSZ 105

First principles study of Al and C-doped MgB_2: evolution of two gaps and critical temperature — •Omar de la Peña-Seaman[1,2], Romeo de Coss[2], Klaus-Peter Bohnen[1], and Rolf Heid[1] — [1]Institut für Festkörperphysik, Forschungszentrum Karlsruhe, Germany — [2]Department of Applied Physics, Cinvestav-Merida, Mexico

We have studied the electron-phonon and superconducting properties of the $Mg_{1-x}Al_xB_2$ and $MgB_{2(1-x)}C_{2x}$ alloys within the framework of density functional perturbation theory, using a mixed-basis pseudopotential method and the virtual crystal approximation (VCA) for modeling the alloys. For both systems, the Eliashberg spectral function ($\alpha^2F(\omega)$) and the electron-phonon coupling parameter (λ) have been calculated in the two band model (σ,π) for several concentrations until x(Al) = 0.55 and x(C) = 0.175. Using the calculated $\alpha^2_{ij}F(\omega)$ and a diagonal expression for the Coulomb pseudopotential matrix, μ^*, we solved numerically the Eliashberg gap equations in the two band model without interband scattering. We reproduce the experimental decreasing behavior of $\Delta_\sigma(x)$, $\Delta_\pi(x)$, and $T_c(x)$ for both alloy systems. The role of the interband scattering in the observed behavior of the superconducting gaps and T_c in the Al- and C-MgB_2 alloys is discussed.

TT 14.2 Tue 9:45 HSZ 105

Electronic Raman scattering in non–centrosymmetric superconductors — •Ludwig Klam[1], Dietrich Einzel[2], and Dirk Manske[1] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany — [2]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

Since their recent discovery, non–centrosymmetric superconductors (NCS) form a rapidly growing field of research and represent a completely new class of superconductors which was believed for a long time not to exist at all. We formulate a theory for the polarization–dependence of the electronic (pair–breaking) Raman response for NCS in the clean limit at zero temperature. Possible applications include the systems $CePt_3Si$ and $Li_2Pd_xPt_{3-x}B$ which reflect the two important classes of the involved spin–orbit coupling.

We provide analytical expressions for the Raman vertices for these two classes and calculate the polarization–dependence of the electronic spectra. We predict a two–peak structure and different power laws with respect to the unknown relative magnitude of the singlet and triplet contributions to the superconducting order parameter, revealing a large variety of characteristic fingerprints of the underlying condensate.

TT 14.3 Tue 10:00 HSZ 105

Electronic structure of $SrPt_4Ge_12$: a study by soft x-ray photoelectron spectroscopy and band structure calculations — •Jan Gegner[1], David Regesch[1], Helge Rosner[2], Walter Schnelle[2], Roman Gumeniuk[2], Andreas Leithe-Jasper[2], Hidenori Fujiwara[1], Tim Haupricht[1], H. -H. Hsieh[3], H. -J. Lin[4], C. T. Chen[4], Alim Ormeci[2], Juri Grin[2], and Liu Hao Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln, Germany — [2]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany — [3]Chung Cheng Institute of Technology, National Defense University,Taoyuan, Taiwan — [4]National Synchrotron Radiation Research Center (NSRRC), Hsinchu, Taiwan

We present a comparative study of the electronic structure of the superconducting skutterudite $SrPt_4Ge_{12}$ by means of soft x-ray photoelectron spectroscopy and full potential band structure calculations. Excellent agreement between the measured and the calculated valence spectra is observed, confirming the picture of rather localized, low lying Pt 5*d* states compared to Pt metal. This implicates that the states at the Fermi level stem predominantly from Ge 4*p* electrons. An analysis of the chemical bonding in $SrPt_4Ge_{12}$ based on the electron localizability indicator is given.

Invited Talk TT 14.4 Tue 10:15 HSZ 105

Evidence for a novel superconducting state in high magnetic fields — •Joachim Wosnitza — Hochfeld-Magnetlabor Dresden (HLD), Forschungszentrum Dresden-Rossendorf, Germany

In the so-called FFLO state, named after Fulde, Ferrell, Larkin, and Ovchinnikov, the superconducting state can survive even at high magnetic fields above the Pauli paramagnetic limit. The quasi-two-dimensional (2D) organic superconductors have been suggested as good candidates for exhibiting the FFLO state. When applying the magnetic field exactly parallel to the conducting layers the orbital pair breaking is greatly suppressed and the Pauli limit is reached. We performed high-resolution specific-heat and torque-magnetization experiments in magnetic fields up to 32 T for such 2D organic superconductors. In a very narrow region close to parallel orientation we observe additional anomalies below the upper critical field signalling the existence of an additional superconducting phase. The specific-heat data for κ-(BEDT-TTF)$_2$Cu(NCS)$_2$ with $T_c = 9.1$ K show that the superconducting transition becomes first order for fields above 21 T indicating that the Pauli limit is reached. Below about 3 K, the upper critical field increases sharply and a second first-order transition appears within the superconducting phase. Our results give strong evidence for the realization of the FFLO state in organic superconductors.

Work done in cooperation with R. Lortz, B. Bergk, Y. Wang, A. Demuer, I. Sheikin, G. Zwicknagl, and Y. Nakazawa.

15 min. break

TT 14.5 Tue 11:00 HSZ 105

Doping effect on Pauli limited superconductor $CeCoIn_5$ — •Yoshi Tokiwa — I. Physik. Institut, Georg-August Universitat Gottingen, Friedrich-Hund Platz 1, 37077 Göttingen

We present a study on the proposed FFLO state in the strongly Pauli limited superconductor $CeCoIn_5$ by measuring specific heat of slightly Hg- and Sn-doped compounds, $CeCo(In_{1-x}Hg_x)_5$ and $CeCo(In_{1-x}Sn_x)_5$ with x from 0.01 to 0.08%. The high-field low-temperature (HFLT) superconducting (SC) phase exhibits an extreme sensitiveness to the doping, i. e., HFLT phase being suppressed by ∼0.05% of Hg-doping or ∼0.08% of Sn-doping. Our results suggest a possible relation between the characteristic length scale of HFLT phase and SC coherence length. Interestingly, the HFLT transition temperature T_{HFLT} increases with increasing Hg-doping concentration, while it decreases as Sn is doped. A plot of T_{HFLT} vs T_c at high fields with doping concentration as an implicit parameter shows a scaling of the two, $T_{HFLT} \propto T_c$. We conclude that these results imply SC origin of the HFLT state rather than antiferromagnetism.

This work has been done by the collaboration with R. Movshovich, F. Ronning, E. D. Bauer, J. D. Thompson, P. Papin, A. D. Bianchi, J. F. Rauscher, S. F. Kauzlarich and Z. Fisk.

TT 14.6 Tue 11:15 HSZ 105

Superconducting properties of hydrogen under pressure — Pierluigi Cudazzo[1], Gianni Profeta[1], •Antonio Sanna[2], Andrea Floris[2], Alessandra Continenza[1], Sandro Massidda[3], and E.K.U. Gross[2] — [1]CNISM Dipartimento di Fisica, Universita' degli studi dell'Aquila, L'Aquila Italy — [2]Institut fuer Theoretishe Physik Freie Universitaet, Berlin — [3]SLACS-INFM Dipartimento di Fisica Universita' degli Studi di Cagliari, Cagliari Italy

We present first-principles calculations of the superconducting properties of molecular metallic hydrogen under pressure[1], obtained within the density functional theory of superconductivity [2]. Our study is able to single out the features which drive the system towards superconductivity: mainly, a rich and complex Fermi surface and strongly coupled phonon modes driving the intra- or intermolecular charge transfer. We predict three-gap superconductivity and a critical temperature that rises with increasing pressure up to 242 K at 450 GPa. Our study clearly demonstrates that a very high superconducting critical temperature can be reached purely from electron-phonon and Coulombic electron-electron interactions, thus confirming Ashcroft's early speculations[3].

[1] P. Cudazzo *et al.*, Phys. Rev. Lett **100**, 257001 (2008).
M. Lüders *et al.*, Phys. Rev. B **72**, 024545 (2005).
M. A. L. Marques *et al.*, Phys. Rev. B **72**, 024546 (2005).
[2] L. N. Oliveira, E. K. U. Gross, and W. Kohn, Phys. Rev. Lett **60**, 2430 (1988).
[3] N. Ashcroft, Phys. Rev. Lett. **21** 1748 (1968).

TT 14.7 Tue 11:30 HSZ 105

Superconductivity in quasi-2D systems within the BCS approach: Predictions of high-T_c superconductivity in hydrogen-graphite system — •Nicolas Garcia and Pablo Esquinazi — Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig

Using the BCS approach, the local density and phonon spectra we calculate the superconducting gap at $T = 0$ K for metalizing hydrogen in a 2D graphene system. The aim is to estimate the critical temperature in quasi 2D graphite-hydrogen system. The calculation is done as a function of the density of conduction electrons n induced by the hydrogen and their effective mass. The results indicate that for $n \sim 5{\times}10^{14}$ cm^{-2} and an effective mass equal to the free electron mass, the superconducting gap has a maximum of 40K with a Maxwell-like distribution as a function of n. The results provide a possible explanation for the recently reported granular superconducting-like behavior in graphite and multigraphene samples.

TT 14.8 Tue 11:45 HSZ 105

Functional renormalization for antiferromagnetism and superconductivity in the Hubbard model — •Simon Friederich — Institut fuer Theoretische Physik, Universitaet Heidelberg

Results of a renormalization group study for the 2-dimensional Hubbard model close to half-filling at finite temperature are presented. Bosonic degrees of freedom corresponding to antiferromagnetic and d-wave superconducting order are introduced, and flow equations for the corresponding coupling constants are deduced from an exact flow equation for the effective average action.

The influence of bosonic fluctuations on the onset of local antiferromagnetic oder is discussed. At low enough temperatures and close to half-filling the discrete symmetry of the lattice is broken and incommensurate antiferromagnetic fluctuations dominate. The phase diagram is shown for the parameter regime close to half-filling in the presence of vanishing as well as non-vanishing next-to-nearest-neighbor hopping t'.

Finally, the potential emergence of d-wave superconducting order at larger distances from half-filling is discussed.

TT 14.9 Tue 12:00 HSZ 105

Discontinuity of capacitance at the onset of surface superconductivity — •Klaus Morawetz[1,2], Pavel Lipavsky[3,4], and Jiri Mares[4] — [1]Forschungszentrum Dresden-Rossendorf, PF 51 01 19, 01314 Dresden, Germany — [2]International Center for Condensed Matter Physics, 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

The effect of the magnetic field on a capacitor with a superconducting electrode is studied within the Ginzburg-Landau approach. It is shown that the capacitance has a discontinuity at the onset of the surface superconductivity which is expressed as a discontinuity in the penetration depth of the electric field into metals. This new effect establishes a macroscopic signal of the onset of superconducting correlations. This discontinuity is observable with recent bridges for both conventional and high-T_c superconductors.

Phys. Rev. B 78 (2008) 054525-1-13