TT 33: Superconductivity, Measuring Devices, Matter at Low Temperature: Poster Session

We recommend to hang up the posters already during the morning sessions.

Time: Wednesday 15:00–19:00 Location: Poster B

TT 33.1 Wed 15:00 Poster B

Magnetic investigations on $EuFe_2(As_{1-x}P_x)_2$ single crystals — •Felix Klingert[1], Sina Zapf[1], Dan Wu[1], Shuai Jiang[1,2], Hirale S. Jeevan[2], Philipp Gegenwart[2], and Martin Dressel[1] — [1]1.Physikalisches Institut, Universität Stuttgart, Germany — [2]I.Physikalisches Institut, Universität Göttingen, Germany

Magnetic susceptibility measurements on a series of $EuFe_2(As_{1-x}P_x)_2$ single crystals (x = 0, 0.05, 0.12, 0.25, 0.35) show, how the isovalent P substitution on the As site influences the magnetic ordering of the Eu^{2+} spins, which appears at low temperatures additionally to the spin-density-wave (SDW) or superconducting (SC) phase of the Fe subsystem. Thus this system provides an extraordinary possibility to study the interplay of magnetism and SC.

The Eu^{2+} moments order ferromagnetic (FM) in the ab-plane, but depending on the P content the interlayer coupling develops from antiferromagnetic (in the SDW- and SC-phase) to ferromagnetic coupling (for high substitution). We have previously reported low field magnetization measurements, showing an additional canting of Eu^{2+} spins out of the plane, which leads to a FM component along the c-direction and gets stronger with the suppression of the SDW ordering of Fe [1]. We have now performed a detailed study on a series of samples, which includes angle dependent magnetization measurements, investigating in detail the interplay of Fe and Eu magnetic ordering.

[1] S. Zapf et al., PRB(R) 84, 140503

TT 33.2 Wed 15:00 Poster B

Temperature dependent ellipsometric Studies on Iron-Pnictides — •Mathias Eichler, Dan Wu, Bruno Gompf, and Martin Dressel — 1. Physikalisches Institut, Universität Stuttgart

Iron-pnictides indicate a strong temperature dependence in their optical properties even at high energies. The aim of the present work is spectroscopic ellipsometry measurements on iron-pnictides performed as a function of temperature. To accomplish this task we use a Woollam Variable Angle Spectroscopic Ellipsometer (VASE) operating in the spectroscopic range from 4,000cm^{-1} to 40,000cm^{-1}. The setup is equipped with a customized Janis ST-400 liquid helium cryostat that allows us to measure at temperatures down to 5 K. In order to measure small samples with 1×1 mm^2 in size the setup was improved by upgrading the sample stage geometry to yield an undisturbed signal. The final design also allows us to compensate thermal expansion effects and to easily align the crystal within the cryostat. With this advanced setup, we have investigated several families of 122-pnictides, for example the series $EuFe_2(As_{1-x}P_x)_2$. We find a significant shift of the spectral weight with temperature. The results on other compounds will be also discussed, e.g. different doping levels.

TT 33.3 Wed 15:00 Poster B

Isovalent substitution on the iron site in pnictides - an optical study — •Daniel Pröpper[1], Aliaksei Charnukha[1], Ma Jin Eom[2], Jun Sung Kim[2], Bernhard Keimer[1], and Alexander Boris[1] — [1]Max-Planck-Institute for Solid State Research, Stuttgart, Germany — [2]Department of Physics, Pohang University of Science and Technology, Pohang, Korea

Here we report on the full complex dielectric function $\epsilon(\omega)$ in the *ab* plane of $Ba(Fe_{1-x}Ru_x)_2As_2$ applying spectroscopic ellipsometry in the broad range of 60 meV to 6 eV. The investigated set of samples spans the whole range from the parent compound $BaFe_2As_2$ deep into the overdoped regime (x = 0.74), not reported so far, showing superconductivity with T_c up to 20 K at optimally doping (x = 0.35). By classical dispersion analysis of Drude-Lorentz type we detect an increase in the bare plasma frequency ω_p, associated with the free carrier response, and a significant decrease of the low-energy dielectric permittivity ϵ_∞ upon doping. The main contribution to ϵ_∞ arises from the lowest lying interband transitions at ~ 0.5 eV, assigned to be from Fe(Ru)-d/As-p to Fe(Ru)-d hybrid states [1]. This gives rise to anomalously high $\epsilon_\infty \approx 60 - 80$ among all other high-T_c superconductors. This, in conjunction with increased Fe(Ru)-d bandwidth with x due to stronger hybridization with As-p states [2], hints to a strong decrease in the high polarizability of Fe-As bonds, which is thought to play a crucial role in establishing and controlling superconductivity in iron pnictides.

[1] A. Charnukha et al., Nat. Comm. 2 (2011), 219
[2] L. Zhang et al., PRB 79 (2009), 174530

TT 33.4 Wed 15:00 Poster B

Evidence for vortex lattice melting in $Ba_{1-x}K_xFe_2As_2$ seen by thermal expansion — •Philipp Burger[1,2], Anna Böhmer[1,2], Frédéric Hardy[1], Peter Adelmann[1], Doris Ernst[1], Rainer Fromknecht[1], Peter Schweiss[1], Thomas Wolf[1], Hilbert von Löhneysen[1,3], and Christoph Meingast[1] — [1]Institut für Festkörperphysik, Karlsruher Institut für Technologie, 76021 Karlsruhe, Germany — [2]Fakultät für Physik, Karlsruher Institut für Technologie, 76128 Karlsruhe, Germany — [3]Physikalisches Institut, Karlsruher Institut für Technologie, 76128 Karlsruhe, Germany

Low temperature thermal expansion measurements have been performed on underdoped (T_c=30.6 K) and overdoped (T_c=33.8 K) $Ba_{1-x}K_xFe_2As_2$ single crystals in magnetic fields up to 10T applied perpendicular to the Fe-As layers. The superconducting transition for the underdoped sample broadens strongly with increasing magnetic field due to strong fluctuations, whereas for the overdoped sample it simply shifts to lower temperatures. Upon heating (after cooling in constant field) we observe a sharp peak in the expansion coefficients at a temperature slightly lower than T_c. These peaks are absent in the cooling curves. We associate these peaks with an underlying thermodynamic melting of the vortex lattice, since our results are very similiar to previous thermal expansion data [1] of YBCO, which clearly exhibits a first-order vortex melting transition.

[1] R. Lortz *et al.*, J. Low Temp. Phys **147**, 365 (2007)

TT 33.5 Wed 15:00 Poster B

Thermal expansion and magnetostriction studies on Fe-based pnictides — •Christopher Dietl[1], Norman Leps[1], Liran Wang[2], Ulrike Stockert[3], Luminita Harnagea[4], Sabine Wurmehl[4], Bernd Büchner[4], and Rüdiger Klingeler[1] — [1]Kirchhoff-Institute for Physics,University of Heidelberg, Heidelberg, Germany — [2]National High Magnetic Field Laboratory, Tallahassee,Florida, USA — [3]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [4]Leibniz Institute for Solid State and Materials Research, IFW Dresden, Dresden, Germany

We investigate the thermal expansion coefficient α and the magnetostriction β of single crystalline $Ca(Fe_{1-x}Co_x)_2As_2$ and polycrystalline $RFeAsO_{1-x}F_x$. The data are obtained by means of a high-resolution capacitive dilatometer consisting of silver. For $CaFe_2As_2$, the SDW-type magnetic and structural phase transition causes a pronounced anomaly which shifts, splits, and broadens upon doping. The structural phase diagram is constructed and particular emphasis is given to the paramagnetic tetragonal phase where a linear temperature dependence of the length changes is observed.

TT 33.6 Wed 15:00 Poster B

Coherent excitations and e-ph coupling in 122 FeAs compounds investigated by time-resolved ARPES — •I. Avigo[1], R. Cortés[2,3], L. Rettig[1,2], S. Thirupathaiah[4], H. S. Jeevan[5], P. Gegenwart[5], T. Wolf[6], M. Ligges[1], M. Wolf[2,3], J. Fink[4], and U. Bovensiepen[1,2] — [1]Universität Duisburg-Essen — [2]Freie Universität Berlin — [3]Fritz-Haber-Institut d. MPG, Berlin — [4]IFW Dresden — [5]Georg-August Universität Göttingen — [6]Karlsruhe Institute of Technology

We investigate the coupling of low energy electrons to lattice vibrations in iron based high-T_c superconductors to shed light on the mechanisms leading to superconductivity. Femtosecond time and angle-resolved photoemission spectroscopy was employed to analyze the response of the electronic system of 122 iron pnictide compounds to optical excitation. Oscillations of the spectral weight around the Fermi level were observed showing three different coherently excited phonon modes. We identify the symmetric A_{1g} mode at 5.6 THz, corresponding to the displacement of the As atoms perpendicular to the Fe-plane, and two further modes at 3.3 THz and 2.6 THz. Our observations are consistent with calculations predicting strong e-ph coupling for the A_{1g} mode. By analyzing the rate of energy relaxation of excited electrons we estimate the moment-averaged e-ph coupling constant to $\lambda < 0.2$

which makes simple e-ph interaction an unlikely pairing candidate for superconductivity. This work has been funded by the DFG through BO 1823/2 and SPP 1458. R.C. acknowledges the Alexander von Humboldt Foundation.

TT 33.7 Wed 15:00 Poster B

Three-dimiensional Fermi surface of Iron-pnictide superconductor $Ba_{1-x}K_xFe_2As_2$ — •Masaki Kobayashi[1,2], Vladimir N. Strocov[1], Elia Razzoli[1,3], Ming Shi[1], Thorsten Schmitt[1], Xiaoping Wang[1,4], Yaobo Huang[4], Hong Ding[4], Masaharu Oshima[2], and Luc Patthey[1] — [1]Swiss Light Source, Paul Scherrer Institut, Villigen, Switzerland — [2]Department of Applied Chemistry, University of Tokyo, Tokyo, Japan — [3]Laboratory for Synchrotron and Neutron Spectroscopy, EPFL, Lausanne, Switzerland — [4]Institute of Physics, Chinese Academy of Science, Beijing, China

Iron-based superconductors have attracted much attention because of the unexpected high transition temperatures of the superconducting state. Investigation of bulk three-dimensional electronic structure will provide further understanding of the superconducting properties of $Ba_{1-x}K_xFe_2As_2$ (BKFA). Here, we report investigations of the shape and k_z-dependence of the Fermi surface (FS) in BKFA with soft X-ray ARPES, taking into advantage enhanced bulk sensitivity and intrinsic k_z resolution achieved in the soft-X-ray range.

The experimental FS measured at energies around 900 eV show modulations along the k_z direction corresponding to the Brillouin zone periodicity in BKFA. The in-plane FS shapes alternate between a circle-like and flower-like appearances when going from the Γ point to the higher Brillouin zones. Furthermore, we observed clear polarization dependences of the FS, allowing separation of different valence bands. The results provide with experimental information on the dimensionality and orbital character of FSs of BKFA.

TT 33.8 Wed 15:00 Poster B

Pinning in $CaFe_{2-x}Co_xAs_2$ and $Ba(Fe_{1-x}Co_x)_2As_2$ single crystals as studied by MWA — •Nadezda Panarina[1,2], Niyaz Beysengulov[1], Yuri Talanov[1], Tatyana Shaposhnikova[1], Evgenia Vavilova[1], Luminita Harnagea[2], Saicharan Aswartham[2], Claudia Nacke[2], Sabine Wurmehl[2], Christian Hess[2], Vladislav Kataev[2], and Bernd Büchner[2] — [1]Zavoisky Physical-Technical Institute, Kazan, Russia — [2]IFW Dresden, Germany

Modulated microwave absorption studies were performed on a series of $CaFe_{2-x}Co_xAs_2$ and $Ba(Fe_{1-x}Co_x)_2As_2$ single crystals with different Co content. Investigation of pinning features in these samples is of particular interest since there is a significantly wide region of Co concentration, where the superconducting and magnetic orders coexist. Depending on the scale of such electron phase separation, the nonsuperconducting inclusions present in the samples at certain Co concentration may act as additional pinning centers and influence the pinning strength. To estimate the values of the critical current density, an appropriate theoretical model was applied. By analyzing the magnetic field and temperature dependence of the critical current density, we were able to discriminate different types of pinning (small-bundle and large-bundle pinning) in single crystals of $CaFe_{2-x}Co_xAs_2$ and $Ba(Fe_{1-x}Co_x)_2As_2$. The most effective pinning centers are present in the $CaFe_{2-x}Co_xAs_2$ sample at Co concentration corresponding to the boundary of the coexistence of SDW and superconductivity states. This is due to the best correlation of the sizes of additional nonsuperconducting inclusions with the sizes of vortex cores.

TT 33.9 Wed 15:00 Poster B

In-plane/out-of-plane resistivity anisotropy of Co-doped $BaFe_2As_2$ — •Oleksii Vakaliuk, Manoj Kumar, Saicharan Aswartham, Sabine Wurmehl, Christian Hess, and Bernd Büchner — IFW Dresden

We present an experimental study of the in-plane and out-of-plane electrical resistivities (ρ_{ab}, ρ_c respectively) of $Ba(Fe_{1-x}Co_x)_2As_2$ with x=0; 0.05; 0.075; 0.1; 0.125. The anisotropy $\gamma = \rho_c/\rho_{ab}$ is temperature independent. This suggests an isotropic electron scattering mechanism. We observe a monotonic decrease of γ with changing the doping, suggestive of 2D-3D crossover of the electron structures.

TT 33.10 Wed 15:00 Poster B

Systematic NMR/NQR investigation of the local charge environment in iron pnictides — •Uwe Gräfe[1], Eva-Maria Brüning[1], Guillaume Lang[1], Louis Veyrat[1], Seung-Ho Baek[1], Hans-Joachim Grafe[1], Dalibor Paar[1,2], Franziska Hammerath[1], Katarina Manthey[1], Günther Behr[1], Jochen Werner[1], Sabine Wurmehl[1], and Bernd Büchner[1] — [1]IFW Dresden, Institute for Solid State Research, P.O. Box 270116, D-01171 Dresden, Germany — [2]Dept. of Physics, Faculty of Science, Univ. of Zagreb, P.O. Box 331, HR-10002 Zagreb, Croatia

As iron-based superconductors are a striking example of a system featuring unconventional superconductivity close to a region of static magnetism in the phase diagram, much attention has been devoted to the study of ground-state coexistence and/or competition. In this regard, a more general question is the existence and the role played by electronic inhomogeneities, whether in ordered states or in the paramagnetic state. A powerful tool to investigate these issues is Nuclear Magnetic/Quadrupole Resonance, which allows to probe locally the electric charge environment and the spin fluctuations. Here, we present a summary of recents results and on-going studies at the As site of 1111 iron pnictides.

TT 33.11 Wed 15:00 Poster B

Superconducting LiFeAs as seen by Scanning Tunneling Microscopy/Spectroscopy — •Rico Pohle, Martha Scheffler, Ronny Schlegel, Torben Hänke, Danny Baumann, Anne Bachmann, Dirk Bombor, Steffen Sykora, Luminita Harnagea, Sabine Wurmehl, Christian Hess, and Bernd Büchner — Institut für Festkörperforschung IFW Dresden

Among the entire class of iron-based superconductors the material LiFeAs is of particular interest since an absence of nesting between electron and hole pockets suggests an unconventional type of pairing in this material. Using Scanning Tunnelling Microscopy (STM) and Spectroscopy (STS) we investigate topographic properties of the surface as well as the temperature dependency of the superconducting gap. The good agreement of our results with model calculations for the tunnelling conductance allows us to draw conclusions about the low energy properties of the superconducting system. Furthermore, we compare our results with Transport- and NMR-measurements.

TT 33.12 Wed 15:00 Poster B

Electronic Transport Properties of LiFeAs and Transition Metal doped LiFeAs in comparison to doped and undoped NaFeAs — •Dirk Bombor[1], Anne Bachmann[1], Luminita Harnagea[1], Claudia Nacke[1], Saicharan Aswaratham[1], Igor Morozov[2], Maria Roslowa[2], Sabine Wurmehl[1], Christian Hess[1], and Bernd Büchner[1] — [1]Leibnitz Institute for Solid State and Materials Research, IFW Dresden, Germany — [2]Moscow State University, Moscow 119991, Russia

Electronic transport properties of the unconventional 111-superconductors LiFeAs and NaFeAs as well as its transition metal doped compounds have been studied. Unlike in other iron arsenide superconductors the stoichiometric LiFeAs doesn't show any nesting of the Fermi surface and therefore exhibits no spin density wave but even the undoped compound becomes superconducting below 18 K. We find that doping by substitution of iron with Co, Ni, Cr or Rh suppresses superconductivity. Ferromagnetism in Li-deficient samples is discussed. The isostructural NaFeAs also exhibits superconductivity in its undoped state, but in contrast to LiFeAs a structural and SDW-transitions are found. With Co-doping the SDW-transition can be suppressed and the superconducting transition temperature increased.

TT 33.13 Wed 15:00 Poster B

Superconductivity in LiFeAs — •Johanna Brand[1], Sabine Wurmehl[2], Bernd Büchner[2], Anne Stunault[3], and Markus Braden[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]Leibniz-Institut, Dresden — [3]Institut Laue Langevin, Grenoble

LiFeAs is a member of the family of FeAs based superconductors and is remarkable as it exhibits superconductivity without doping or application of pressure with a sizeable transition temperature, $T_c = 18\,K$. It is still an open question whether the superconducting phase in LiFeAs is characterized by spin singlets or by spin triplets. There are two ways to analyze the magnetic response in the superconducting state as a simple magnetometer study is not possible due to the superconducting shielding: Knight shift and polarized neutron diffraction experiment. We measured flipping ratios with polarized neutron diffraction to follow the spin-susceptibility across T_c. For the magnetic field applied parallel and perpendicular to the c axis we find a drop in the local spin susceptibility which is comparable to the observation for Co-doped $BaFe_2As_2$ suggesting a spin singlet state in LiFeAs.

TT 33.14 Wed 15:00 Poster B

Gutzwiller theory of band magnetism in LaOFeAs — •Tobias Schickling[1], Florian Gebhard[1], Jörg Bünemann[2], Lilia Boeri[3], Ole K. Andersen[3], and Werner Weber[4] — [1]Fachbereich Physik, Philipps Universität, D-35037 Marburg, Germany — [2]Institut für Physik, BTU Cottbus, D-03013 Cottbus, Germany — [3]Max Planck Institute for Solid State Research, D-70569 Stuttgart, Germany — [4]Fakultät Physik, TU Dortmund, D-44221 Dortmund, Germany

For the iron pnictide LaOFeAs we investigate multi-band Hubbard models which are assumed to capture the relevant physics [1, 2]. In our calculations, we employ the Gutzwiller variational theory which is a genuine many particle approach. We will present results both on the paramagnetic and antiferromagnetic phases of our model systems. These results show that a five band-model is not adequate to capture the relevant physics in LaOFeAs [3]. However, our results for the eight band-model which includes the arsenic 4p bands reproduce the experimental data, especially the small magnetic moment, for a broad parameter regime [4].

[1] S. Graser et al., New J. Phys. 11, 025016 (2009).
[2] O. K. Andersen, L. Boeri. Annalen der Physik, 523:8-50 (2011).
[3] T. Schickling et al., PRL, 106:146402 (2011).
[4] T. Schickling et al., arXiv: 1109.0929.

TT 33.15 Wed 15:00 Poster B

Preemptive Nematic Order, Pseudogap, and Orbital Order in the Iron Pnictides — •Johannes Knolle[1], Ilya Eremin[2], Rafael M. Fernandes[3], Andrey V. Chubukov[4], and Jorg Schmalian[5] — [1]Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden, Germany — [2]Institut für Theoretische Physik III, Ruhr-Universität Bochum, D-44801 Bochum, Germany — [3]Department of Physics, Columbia University, New York, New York 10027, USA — [4]Department of Physics, University of Wisconsin-Madison, Madison, Wisconsin 53706, USA — [5]Karlsruher Institut für Technologie, D-76131 Karlsruhe, Germany

Starting from a microscopic itinerant model, we derive and analyze the effective low-energy model for collective magnetic excitations in the iron pnictides. We show that the stripe magnetic order is generally preempted by an Ising-nematic order which breaks C4 lattice symmetry but preserves O(3) spin-rotational symmetry. This leads to a rich phase diagram as function of doping, pressure, and elastic moduli, displaying split magnetic and nematic tri-critical points. The nematic transition may instantly bring the system to the verge of a magnetic transition, or it may occur first, being followed by a magnetic transition at a lower temperature. In the latter case, the preemptive nematic transition is accompanied by either a jump or a rapid increase of the magnetic correlation length, triggering a pseudogap behavior associated with magnetic precursors. Furthermore, due to the distinct orbital character of each Fermi pocket, the nematic transition also induces orbital order. We compare our results to various experiments.

TT 33.16 Wed 15:00 Poster B

Quasiparticle properties in iron arsenides — •Guido Klingschat and Carsten Honerkamp — RWTH Aachen

We calculate the quasiparticle scattering rates and renormalization factors around the various Fermi pockets in multi-band models for iron arsenide superconductors by perturbation theory. The existence of a fifth Fermi pocket is found to have an important influence on the anisotropy of the scattering. We furthermore compare the anisotropies and pocket dependences of the scattering rates with those of the superconducting gaps found in the functional renormalization group and discuss the role of Hund's coupling on these observables.

TT 33.17 Wed 15:00 Poster B

Ultrafast non-equilibrium dynamics in SDW metals — •Bhaskar Kamble[1], Alireza Akbari[2], and Ilya Eremin[1] — [1]Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44801 Bochum — [2]Max Planck Institut für Chemische Physik fester Stoffe, D-01187 Dresden, Germany

We employ a density-matrix theory to analyze the ultrafast dynamics of metallic two-dimensional spin density wave systems on short time scales far away from thermal equilibrium. In particular, we study a non-adiabatic regime where the full account for the time evolution of anomalous expectation values and the coherences between different quasiparticle states are required. We calculate the time evolution of the SDW mean-field order parameter and compare its behavior with that of a superconductor. In addition, we discuss the transition between the adiabatic and the non-adiabatic regimes, where the order parameter oscillates, and a description in terms of the quasiparticle occupations becomes insufficient.

TT 33.18 Wed 15:00 Poster B

Robustness of surface states in noncentrosymmetric superconductors — •Raquel Queiroz and Andreas Schnyder — Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany

Noncentrosymmetric superconductors, where spin singlet and triplet pairing states are mixed, exhibit topologically protected zero-energy flat bands localized on the surface [1-3]. The region of the surface Brillouin zone where these states appear is bounded by the projections of the nodal lines of the bulk gap. Using both analytical analysis and numerical simulations, we study the robustness of these surface states against surface roughness and disorder. We show that time-reversal preserving disorder leaves the surface states mostly unaffected. Time-reversal breaking perturbations, on the other hand, such as magnetic impurities, result in a shift of the surface states away from zero energy, but do not change the total amount of ingap states.

[1] A. P. Schnyder and S. Ryu, Phys. Rev. B 84, 060504(R) (2011).
[2] P. M. R. Brydon, A. P. Schnyder, and C. Timm, Phys. Rev. B 84, 020501(R) (2011).
[3] A. P. Schnyder, P. M. R. Brydon, and C. Timm, arXiv/1111.1207 (unpublished).

TT 33.19 Wed 15:00 Poster B

Mössbauer investigation of magnetic and structural phase transitions in $Fe_{1+x}Te$ — •Philipp Materne[1], Cevriye Coz[2], Sahana Rössler[2], Ulrich K. Rössler[3], Mathias Doerr[1], Steffen Wirth[2], Ulrich Schwarz[2], Til Goltz[1], and Hans-Henning Klauss[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Max Planck Institute for Chemical Physics of Solids, Nöthnizer Straße 40, 01187, Dresden, Germany — [3]IFW Dresden, Postfach 270016, 01171 Dresden, Germany

$Fe_{1+x}Te$, the antiferromagnetic parent compound of the Fe-chalcogenide superconductors, displays separated magnetic (T_N) and structural (T_s) transitions with $T_N > T_s$ for $x > 0.12$ [1]. Such behavior, namely the magnetic transition preceeding the structural transition upon cooling, is uncommon for the parent systems of pnictide superconductors. We performed Mössbauer spectroscopy on samples with two representative levels of iron excess: i) $Fe_{1.06}Te$ with simultaneous magnetic and structural transitions at $T_N = T_s$ =69 K and ii) $Fe_{1.13}Te$ with separated transitions at $T_N = 57$ K followed by $T_s = 46$ K. Mössbauer data, analyzed by taking into account two different Fe-sites clearly, display a precursor magnetic state which is only present in $Fe_{1.13}Te$. Further, a complex magnetic phase has been observed in the temperature range 75 K $\gtrsim T \gtrsim$ 40 K in $Fe_{1.13}Te$. We discuss our Mössbauer results in the context of recently published thermodynamic and neutron scattering data on $Fe_{1+x}Te$.

[1] S. Rößler *et al.*, Phys. Rev. B. **84** (2011) 174506.

TT 33.20 Wed 15:00 Poster B

Noise spectroscopy of superconducting systems δ'-FeSe and $FeSe_{0.5}Te_{0.5}$ — •Adham Amyan[1], Amir-Abbas Haghighirad[1], Pintu Das[1], Sahana Rössler[2], Steffen Wirth[2], Dona Cherian[3], Suja Elizabeth[3], Wolf Assmus[1], and Jens Müller[1] — [1]Physikalisches Institut, Goethe-Universität Frankfurt, Frankfurt am Main, Germany — [2]Max-Planck-Institute for Chemical Physics of Solids, Dresden, Germany — [3]Dep. of Physics, Indian Institute of Science, Bangalore, India

One of the most recent interesting and surprising phenomena is superconductivity in Fe-based compound (i.e. pnictides and chalcogenides), where FeSe has the most simple structure of the diverse family of these materials. The $FeSe_{1-x}Te_x$ system shows superconductivity up to $T_c \sim 14$ K. The Fe planar structure may be crucial for understanding the mechanism of superconductivity in these systems: it was suggested that a low temperature structural distortion is closely associated with the superconductiing properties of this material [1]. We employ fluctuation (noise) spectroscopy to study the intrinsic charge carriers dynamics and their correlation with the structural properties. In both superconducting compounds δ'-FeSe and $FeSe_{0.5}Te_{0.5}$ we observe a maximum in the normalized noise power spectral density at 107 K and 110 K respectively, where a structural transition from tetragonal to orthorhombic occurs [2].

[1] M. J. Wang et al, PRL 103, 117002 (2009)
[2] M. de Souza et al, Eur. Phys. J. B 77, 101-107 (2010)

TT 33.21 Wed 15:00 Poster B

Superconductor-insulator transition in disordered FeSe thin films — •Rudolf Schneider, Alexander G. Zaitsev, and Dirk Fuchs — Karlsruher Institut für Technologie, Institut für Festkörperphysik, Karlsruhe, Germany

The evolution of the temperature-dependent sheet resistance with increasing disorder in epitaxial c-axis oriented FeSe thin films was studied. Disorder was induced by decreasing the thickness of identically prepared stoichiometric films. At critical values of the thickness and sheet resistance a transition from the superconducting to the insulating state occurred. The critical sheet resistance was three times the supposed universal quantum resistance for pairs of electrons. Finite-size scaling analysis in the critical regime according to the Bose-glass model revealed a critical exponent product of 7/3 compatible with the prediction of a quantum percolation transition.

TT 33.22 Wed 15:00 Poster B

Superconducting oyxpnictide thin films — •Andreas Reisner[1], Martin Kidszun[1], Thomas Thersleff[2], Elke Reich[1], Bernhard Holzapfel[1], Ludwig Schultz[1], and Silvia Haindl[1] — [1]IFW Dresden, Institute of Metallic Materials, 01069 Dresden, Germany — [2]Uppsala University, Angstrom Laboratory, Box 524, S-751 20 Uppsala, Sweden

We present an overview on the oxypnictide thin film preparation. So far, only $LaAlO_3$ (001) single crystalline substrates provided a successful growth using pulsed laser deposition in combination with a post annealing process. Further experiments on the in-situ deposition will be reported. The structure of the films was investigated by X-ray diffractometry and transmission electron microscopy. Transport properties were measured with different applied fields to obtain a magnetic phase diagram for this new type of superconductor.

TT 33.23 Wed 15:00 Poster B

Unusual flux jumps in MgB_2 thin films — •Sebastian Treiber[1], Claudia Stahl[1], and Joachim Albrecht[2] — [1]Max-Planck-Institut für Intelligente Systeme, Heisenbergstraße 3, 70569 Stuttgart, Germany — [2]Hochschule Aalen, Beethovenstraße 1, 73430 Aalen, Germany

Most superconductors exhibit flux jump phenomena, for example the so called flux avalanches. Below a material dependent threshold temperature - about 10K in case of MgB_2 - flux penetration changes from deterministic to chaotic. In this case, very fast moving vortices form dendritic flux patterns, destroying the critical state along their path. Magneto - optical images show characteristic features of this destruction, like a current - free path of an avalanche. Our experiments have shown, that avalanche behavior can be very different in MgB_2 films with an irregular microstructure [1]. In this contribution, we report on large flux jumps which occur in samples with irregular microstructure at higher temperatures than the classical avalanche temperature. Up to 14K very fast and chaotic flux penetration forms dendritic patterns without destroying the critical state. While SQUID measurements suggest a regular behavior, magneto - optical imaging clearly indicates the presence of large flux jumps.

[1] S. Treiber et al., Phys. Rev. B 84, 094533 (2011)

TT 33.24 Wed 15:00 Poster B

Two concepts of introducing thin-film superconductivity in Ge and Si by use of Ga-ion implantation — •Richard Skrotzki[1,2], Thomas Herrmannsdörfer[1], Jan Fiedler[1], Viton Heera[1], Matthias Voelskow[1], Arndt Mücklich[1], Bernd Schmidt[1], Wolfgang Skorupa[1], Manfred Helm[1], and Joachim Wosnitza[1] — [1]Dresden High Magnetic Field Laboratory (HLD) and Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), P.O. Box 51 01 19, D-01314 Dresden, Germany — [2]Department of Chemistry and Food Chemistry, TU Dresden, 01062 Dresden, Germany

We report on two unconventional routes of embedding superconducting nanolayers in a semiconducting environment. Ion implantation and subsequent annealing have been used for preparation of superconducting thin-films of Ga-doped germanium (Ge:Ga) [1] as well as 10 nm thin amorphous Ga-rich layers in silicon (Si:Ga) [2]. Structural investigations by means of XTEM, EDX, RBS/C, and SIMS have been performed in addition to low-temperature electrical transport and magnetization measurements. Regarding Ge:Ga, we unravel the evolution of T_c with charge-charrier concentration while for Si:Ga recently implemented microstructuring renders critical-current densities or more than 50 kA/cm^2. Combined with a superconducting onset at around 10 K, this calls for onchip application in novel heterostructured devices. This work was supported by EuroMagNET, EU contract 228043.

[1] R. Skrotzki et al., *Low Temp. Phys.* **37**, 1098 (2011)
[2] R. Skrotzki et al., *Appl. Phys. Lett.* **97**, 192505 (2010)

TT 33.25 Wed 15:00 Poster B

Synthesis, structural characterization and superconductivity in La_2Sb — •Stephan Knöner, Elena Gati, Markus Kuhnt, Mariano de Souza, Amir Haghighirad, Wolf Assmus, and Michael Lang — Physikalisches Institut, Goethe-Universität, D-60438 Frankfurt(M), Germany

The discovery of superconductivity in Fe-pnictides has attracted enormous interest to this class of materials [1]. In this contribution, we report on synthesis, structural characterization and magnetic properties of La_2Sb. So far, only little is known on the superconductivity of La_2Sb [2]. This compound possesses a layered quasi-2D structure and crystallizes in a tetragonal structure with space group $I4/mmm$, which is isostructural to the 122-family of the iron pnictides. Since La_2Sb does not contain magnetic ions, it may serve as a reference material to explore the role of magnetic and structural degrees of freedom for superconductivity in iron-pnictides. EPMA and x-ray analyses indicate the phase purity of the samples, which show a superconducting transition at 4.6 K. We will discuss transport and magnetic properties of polycrystalline La_2Sb samples as a function of temperature and will address the effect of hydrostatic pressure.

[1] Y. Kamihara *et al.*, J. Am. Chem. Soc. **130**, 3296 (08)
[2] H. Mizoguchi and H. Hosono, Chem. Commun., **47**, 3778 (11)

TT 33.26 Wed 15:00 Poster B

High-field and low-temperature study of the nanostructured ferromagnetic superconductor Bi_3Ni — •Thomas Herrmannsdörfer[1], Richard Skrotzki[1,2], Rico Schönemann[1], Iurii Scurschii[1], Jochen Wosnitza[1], Daniel Köhler[2], Regine Boldt[3], and Michael Ruck[2] — [1]Dresden High Magnetic Field Laboratory, Helmholtz-Zentrum Dresden-Rossendorf, Dresden — [2]Department of Chemistry and Food Chemistry, TU Dresden, Dresden — [3]Leibniz Institute of Polymer Research, Dresden

We have demonstrated the coexistence of superconductivity and ferromagnetism in Bi_3Ni nanostructures which have been prepared by making use of novel chemical-reaction paths [1]. Here, we present recent experiments on novel nanostructures, such as monodisperse spherical clusters with a diameter of 8 nm as well as nanofibers. We have investigated their magnetic and electrical-transport properties by means of SQUID magnetometry, pulsed-field susceptometry, and ac-resistance measurements in a wide field and temperature range. Pulsed-field susceptibility data up to 60 T allow for a determination of the saturation magnetization of Bi_3Ni nanostructures. Resistivity measurements performed on moderately compacted Bi_3Ni nano fibers down to sub-Kelvin temperatures have shown clear evidence for the existence of an isosbestic point. These results will be presented in the context of a coexistence of superconductivity and ferromagnetism. Part of this work was supported by EuroMagNET, EU-contract No. 228043.

[1] T. Herrmannsdörfer, R. Skrotzki, J. Wosnitza, D. Köhler, R. Boldt, M. Ruck, Phys. Rev. B 83, 140501 (R) (2011).

TT 33.27 Wed 15:00 Poster B

Fermi-surface change in Yb-doped $CeCoIn_5$ — •A. Polyakov[1], O. Ignatchik[1], B. Bergk[1], A.D. Bianchi[2], S. Blackburn[2], B. Prevost[2], M. Cote[2], G. Seyfarth[3], D. Hurt[3], Z. Fisk[3], R.G. Goodrich[4], M. Richter[5], I. Sheikin[6], and J. Wosnitza[1] — [1]Hochfeld-Magnetlabor Dresden (HLD), Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Department of Physics, University of Montreal, Canada — [3]Department of Physics and Astronomy, University of California Irvine, USA — [4]Department of Physics, George Washington University, USA — [5]IFW Dresden, Leibniz Institute for Solid State and Materials Research, Germany — [6]LNCMI-Grenoble, France

The evolution of the band-structure parameters of $Ce_{1-x}Yb_xCoIn_5$ was studied as a function of Yb doping by systematic de Haas–van Alphen (dHvA) measurements. We found only a small change of the dHvA frequencies and effective masses of $CeCoIn_5$ for a low Yb concentrations ($x = 0.1$). A drastic change of the Fermi surface appears for high dilution, i.e., for $x \geq 0.55$. The experimentally observed Fermi-surface topology of $YbCoIn_5$ is in perfect agreement with the calculated band structure. For small x, the effective masses remain strongly renormalized, whereas for $x \geq 0.55$ the masses are reduced dramatically.

Work supported in part by EuroMagNET, EU contract No. 228043.

TT 33.28 Wed 15:00 Poster B

Unconventional strain dependence of superconductivity in Sr_2RuO_4 — •Sebastian Zaum[1,2], Kai Grube[1], Roland Schäfer[1], Florian Hübler[1], Christoph Meingast[1], Yoshiteru Maeno[3], and Hilbert v. Löhneysen[1,2] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, 76021 Karlsruhe, Germany — [2]Karlsruher Institut für Technologie, Physikalisches Institut, 76131 Karlsruhe, Germany — [3]Department of Physics, Kyoto University, Kyoto 606-8502, Japan

In the transition-metal oxide Sr_2RuO_4 unconventional superconductivity emerges presumably near a ferromagnetic ground state. As a result it is generally believed that critical magnetic fluctuations form the pairing mechanism leading to p-wave symmetry of the order parameter. To investigate the coupling of superconductivity to the crystal lattice we measured the thermal expansion of Sr_2RuO_4 single crystals in a temperature range between 20 mK and 10 K. The uniaxial pressure and strain dependences of the superconducting transition temperature along the tetragonal a and c axes were determined by using the Ehrenfest relation and the elastic constants. Although the layered crystal structure suggests a strongly anisotropic behavior, the strain dependences of T_c are nearly of the same size for both axes. In contrast to many conventional superconductors, the temperature dependence of the linear thermal expansion coefficients along the a and c axes are not proportional to each other. Such a difference indicates that the superconducting ground state is controlled by more than one characteristic energy scale.

TT 33.29 Wed 15:00 Poster B

Berry curvature and orbital magnetization of the triplet superconductor Sr_2RuO_4 — •Martin Gradhad, James F. Annett, and Balazs L. Györffy — University of Bristol, H.H. Wills Physics Laboratory, Tyndall Avenue, Bristol BS8 1TL, UK

The strong experimental evidence of spin triplet pairing in the superconducting phase of Sr_2RuO_4 prompts an interest in a detailed material dependent study of orbital magnetization in this exotic superconductor. [1] Evidently, the modern theory of orbital magnetization for metals, when generalized for the case of superconductors, would shed interesting light on the superconducting state which brakes time-reversal symmetry.

Here we present first principles as well as tight binding calculations of the Berry curvature in the normal state of Sr_2RuO_4 to show the reliability of the tight binding model. Since spin-orbit coupling is an essential ingredients of the problem a fully relativistic Greens-function method is applied to the calculation of the Berry curvature. [2] In a next step the tight binding model is used to describe the superconducting phase by solving the Bogolubov-de Gennes equation [3] and new contributions to the Berry curvature will be discussed.

[1] Y. Maeno et al. Phys. Today **54** (1), 42 (2001)
[2] M. Gradhand et al. Phys. Rev. B **84**, 075113 (2011)
[3] J.F. Annett et al. Phys. Rev. B **66**, 134514 (2002)

TT 33.30 Wed 15:00 Poster B

Direct observation of the superconducting energy-gap opening in the optical conductivity spectra of $LuNi_2B_2C$ — •Theo Fischer[1], A. V. Pronin[1], D. Stehr[1], J. Wosnitza[1], T. Niemeier[2], and B. Holzapfel[2] — [1]Hochfeld-Magnetlabor Dresden (HLD) and Institute of Ion Beam Physics and Materials Research, HZ Dresden-Rossendorf, 01314 Dresden, Germany — [2]IFW Dresden, Leibniz Institute for Solid State and Materials Research, Germany

At frequencies between 100 GHz and 2.5 THz, we have accurately measured the complex transmission coefficient of $LuNi_2B_2C$ films on MgO substrates using two different setups: a time-domain terahertz spectrometer and a setup based on backward-wave oscillators. For the first time, the development of the superconducting energy gap is directly observed in the optical spectra. From the measured data, we have calculated the optical conductivity and the penetration depth. We have compared the results with the BCS theory, and found an additional absorption at low frequencies. The origin of this absorption may be related to the complex gap structure of the compound with possible nodes. Theoretical calculations are currently under way. Part of this work has been supported by EuroMagNET, EU contract 228043.

TT 33.31 Wed 15:00 Poster B

Fluctuation conductivity in small superconducting cylinders — •Brian Tarasinski and Georg Schwiete — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

By threading a magnetic flux through mesoscopic superconducting cylinders with diameter comparable to the superconducting coherence length ξ, it is possible to suppress superconductivity, leading to a destructive regime around half integer flux quanta.

Recently, transport experiments on small superconducting cylinders have been reported, in which the destructive regime could be observed [1,2]. We study theoretically the fluctuation conductivity on the normal side of the transition with particular emphasis on the low temperature regime.

[1] Y. Liu et al., Science 294, 2332 (2001).
[2] I. Sternfeld et al., Phys. Rev. Lett. 107, 037001 (2011)

TT 33.32 Wed 15:00 Poster B

Anisotropic magneto-transport in a Bi-2201 high-T_c superconductor — •Thorsten Jacobs[1], Sven-Olof Katterwe[1], Andreas Rydh[1], Holger Motzkau[1], Toni Helm[2], Mark V. Kartsovnik[2], Andrey Maljuk[3], Erik Kampert[4], Frederik Wolff-Fabris[4], and Vladimir M. Krasnov[1] — [1]Department of Physics, Stockholm University, AlbaNova University Center, 10691 Stockholm, Sweden — [2]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, 85748, Garching, Germany — [3]Leibniz Institute for Solid State and Materials Research IFW Dresden, 01171 Dresden, Germany — [4]Hochfeld-Magnetlabor Dresden, Helmholtz Zentrum Dresden-Rossendorf, 01328 Dresden, Germany

The single-CuO_2 plane cuprate superconductor $Bi_{2+x}Sr_{2-y}CuO_{6+\delta}$ is characterized by a relatively low critical temperature and upper critical field. This allows for a complete suppression of superconductivity at low T and thus opens a possibility to study the normal-state properties with a low interference of thermal fluctuations.

We present magnetotransport measurements of small mesa structures (1 to 25 μm^2) of Bi-2201 single crystals with a T_c of only ~ 4 K. The tunneling conductance in the superconducting state exhibits gap-like characteristics that vanish at T_c or at a modest $H_{c2} \sim 10$ T. However, a profound negative c-axis magnetoresistance persists in the normal-state without saturating at fields up to $H = 65$ T. This is likely due to a magnetic field suppression of an antiferromagnetic or spin/charge density wave order and provides evidence for a different origin of superconductivity and the pseudogap in cuprates.

TT 33.33 Wed 15:00 Poster B

Asymmetric resistive switching in $Bi_2Sr_2CaCu_2O_{8+x}$ single crystals — •Holger Motzkau, Thorsten Jacobs, Sven-Olof Katterwe, Andreas Rydh, and Vladimir M. Krasnov — Experimental Condensed Matter Physics, Department of Physics, Stockholm University, AlbaNova University Center, 106 91 Stockholm, Sweden

We study resistive switching phenomena in small mesa structures on top of $Bi_2Sr_2CaCu_2O_{8+x}$ (Bi-2212) and $Bi_{1.75}Pb_{0.25}Sr_2CaCu_2O_{8+x}$ (Bi(Pb)-2212) single crystals. We manipulate the normal state resistance of the mesa by a bias voltage as well as short current pulses, and study current-voltage characteristics, magnetoresistance, and the temperature dependence of the resistance. Indications of several different switching mechanisms are found, including asymmetric, current directional dependent changes of the resistance, and filamentary breakdown. We find that resistive changes from a fairly gentle biasing is accompanied by a clear influence on the superconducting properties, including critical current, critical temperature, and gap voltage. Our findings indicate that ion transport may occur at the conditions where resistive switching takes place, and therefore should not be neglected in the interpretation of resistive switching mechanisms of Bi-2212.

TT 33.34 Wed 15:00 Poster B

Polarization dependence of (Bi,Pb)-2201 and (Bi,Pb)-2212 low energy excitations by variable polarization ARPES — •Peter Hlawenka, Robin Weyrich, Aliakbar Ghafari, Christoph Janowitz, Helmut Dwelk, Alica Krapf, and Recardo Manzke — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin, Deutschland

The low energy excitations at the M-points of the four quadrants of the first Brillouin zone of superstructure free (Bi,Pb)-2201 and (Bi,Pb)-2212 single crystals have been investigated systematically with respect to their polarization dependence. A new spectrometer with a SCIENTA SES100 and HeI radiation from a duoplasmatron source was used. A polarizer with focusing capability enabled a continuous variation of the polarization vector in the CuO_2- plane. Like previously reported[1] the topmost emission consists of two peaks, whose relative

intensity varies with the selected polarization and also the M-point under study, showing the M points to be essentially not equivalent. Possible reasons will be discussed taking also the results of temperature and photon energy dependent measurements into account.
[1] R. Manzke, R. Müller, C. Janowitz, M. Schneider, A. Krapf, H. Dwelk; Phys. Rev. B 63, R100504 (2001)

TT 33.35 Wed 15:00 Poster B

Momentum-dependend quasiparticle relaxation dynamics in Bi2212 investigated by trARPES above and below T_c — •S. Freutel[1], R. Cortés[1,2], L. Rettig[1,2], Y. Yoshida[3], H. Eisaki[3], M. Ligges[3], M. Wolf[4], and U. Bovensiepen[1,2] — [1]Univ. Duisburg-Essen — [2]Freie Univ. Berlin — [3]NIAIST, Tsukuba, Japan — [4]Fritz-Haber-Institut d.MPG, Berlin

After more than two decades of research, the understanding of high temperature superconductivity is still one of the most challenging problems of solid state physics. Femtosecond, time- and angle-resolved photo electron spectroscopy has proven to be a powerful technique to investigate the quasiparticle dynamics after optical excitation of these materials. Recent work on the optimally doped high-T_c superconductor $Bi_2Sr_2CaCu_2O_{2+\delta}$ [1] studied the decay times of photoexcited quasiparticles well below the transition temperature T_c at different electron momenta along the Fermi surface. At $T < T_c$ the relaxation times exhibit no sign of a momentum dependency which was explained by blocked electron-electron scattering channel towards the nodal region due to phase space restrictions originating from the superconducting gap. Here we report independent evidence of this explanation. Since the gap vanishes at $T > T_c$ an onset of a momentum dependence in the relaxation time would support our earlier conclusion [1]. Analyzing Bi2212 at 100 K we find a clear decrease of the relaxation time towards the nodel line from 800fs at a Fermi Surface angle of 18° to 300fs at 45°.
[1] Cortés et al., Phys. Rev. Lett., 107, 097002 (2011)

TT 33.36 Wed 15:00 Poster B

Correlated heterostructures with dynamical mean field theory — •Christoph Schütte and Achim Rosch — Institut für theoretische Physik, Universität zu Köln, Germany.

The interfaces between different materials in three-dimensional nanostructures give rise to interesting electronic phenomena such as metallic or even superconducting layers between insulators. We calculate various transport coefficients for different heterostructures as a function of temperature. The interactions in the structure may be described by the Hubbard model with an additional self-consistent treatment of long-range Coulomb interactions in a Hartree approximation. Inhomogeneous Dynamical Mean Field Theory (DMFT) is employed to calculate the electronic structure of such a multilayered device in three spatial dimensions. The subsequent single impurity Anderson model (SIAM) is solved with the numerical renormalisation group (NRG), a non-perturbative method which yields the accurate low-temperature properties.

TT 33.37 Wed 15:00 Poster B

Charge carrier density at the (Na/K)TaO_3/$SrTiO_3$ interfaces — •Udo Schwingenschlögl and Safdar Nazir — KAUST, PSE Division, Thuwal 23955-6900, Kingdom of Saudi Arabia

The formation of a quasi two-dimensional electron gas between the band insulators $NaTaO_3$ and $SrTiO_3$ as well as $KTaO_3$ and $SrTiO_3$ is studied by means of the full-potential linearized augmented plane-wave method of density functional theory. Optimization of the atomic positions points to only small changes in the chemical bonding at the interface. The creation of metallic interface states thus is not affected by structural relaxation but can be explained by charge transfer between transition metal and oxygen atoms. It is to be expected that a charge transfer is likewise important for related interfaces such as $LaAlO_3$/$SrTiO_3$. Both the p-type $(NaO)^-/(TiO_2)^0$ and n-type $(TaO_2)^+/(SrO)^0$ interfaces in $NaTaO_3$/$SrTiO_3$ are found to be metallic with strongly enhanced charge carrier densities as compared to the respective interfaces in $KTaO_3$/$SrTiO_3$. The effects of O vacancies are discussed. Spin-polarized calculations point to the formation of isolated O 2p magnetic moments, located in the metallic region of the p-type interface. The systems under investigation are suitable for disentangling the complex behavior of metallic interface states, since the structural relaxation is small.

TT 33.38 Wed 15:00 Poster B

Preparation and characterization of $LaAlO_3$/$SrTiO_3$ heterostructures — •Ahmed Sleem[1,2], Dirk Fuchs[1], Rudolf Schneider[1], and Hilbert von Löhneysen[1,3] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, 76021 Karlsruhe, Germany — [2]Karlsruher Institut für Technologie, Fakultät für Physik, 76031 Karlsruhe, Germany — [3]Karlsruher Institut für Technologie, Physikalisches Institut, 76031 Karlsruhe, Germany

Thin films of $LaAlO_3$ were grown epitaxially by pulsed laser deposition on TiO_2 terminated <001> oriented $SrTiO_3$ substrates. The deposition parameters, i. e., substrate temperature T_S, oxygen partial pressure $P(O_2)$ and the laser fluence F on the target were optimized with respect to the interface conductivity of the heterostructure. For this purpose, contacts through the $LaAlO_3$ layer were prepared by argon ion-etching down to the interface and subsequent hole-filling with Pt or direct bonding of Al-wires. Metallic behavior down to $T = 4.2$ K was found only in a very narrow range of T_S, F and $P(O_2)$. Experimental results with respect to the characterization of the surface and substrate termination, the structural properties and interface conductivity obtained by atomic force microscopy, x-ray diffraction and high resolution electron microscopy, and resistivity measurements, respectively, will be presented and discussed.

TT 33.39 Wed 15:00 Poster B

Torque magnetometry on $SrTiO_3$-$LaAlO_3$ heterostructures — •Matthias Brasse[1], Rainer Jany[2], Marc A. Wilde[1], and Dirk Grundler[1] — [1]Lehrstuhl für Physik funktionaler Schichtsysteme, Technische Universität München, Physik Department, James-Franck-Str.1, D-85747 Garching b. München, Germany — [2]Experimentalphysik VI, Institut für Physik, Universität Augsburg

Two-dimensional electron systems (2-DESs) have been found to form at the interface between the otherwise insulating oxides $LaAlO_3$ and $SrTiO_3$. The strongly correlated electron system shows a metallic phase and coexistence of superconductivity and magnetism at low temperatures. To explore the nature of the magnetic phase we use highly sensitive micromechanical torque magnetometry. This technique allows us to address different phenomena such as the de Haas-van Alphen effect, dia- and paramagnetism in superconducting states as well as magnetic hysteresis and anisotropy in case of correlated magnetism. Methods and results of ongoing measurements will be presented. We thank R. Jany and the group of J. Mannhart from the University of Augsburg for sample preparation. This work is supported by the DFG via TRR 80.

TT 33.40 Wed 15:00 Poster B

Thin film $YBa_2Cu_3O_7$ junctions with $La_{2/3}Ca_{1/3}MnO_3$ barrier — •Matthias Hepting, Andreas Stöhr, Robert Werner, Reinhold Kleiner, and Dieter Koelle — Physikalisches Institut – Experimentalphysik II and Center for Collective Quantum Phenomena in LISA$^+$, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

We report on the fabrication and electric transport properties of thin film $YBa_2Cu_3O_7$ (YBCO) junctions with $La_{2/3}Ca_{1/3}MnO_3$ (LCMO) barrier. Heteroepitaxial YBCO/LCMO/YBCO multilayers were grown in-situ by pulsed laser deposition and subsequently patterned by photolithography and Ar ion milling to form rectangular junctions with typical area $5\,\mu m \times 30\,\mu m$. A self-alignment process was used for electrical contact via an Au wiring layer to the upper YBCO electrode, smilarly as decribed in [1]. Samples were characterized at temperature $T = 4.2$ K either in magnetically shielded environment or in in-plane magnetic fields B up to the Tesla range. We will present and discuss current-voltage-characteristics and measurements of critical current vs B.
[1] J. Tomaschko et al., Phys. Rev. B **84**, 064521 (2011).

TT 33.41 Wed 15:00 Poster B

$YBa_2Cu_3O_7$ nanoSQUIDs for detection of small spin systems — •Tobias Schwarz[1], Joachim Nagel[1], Roman Wölbing[1], Matthias Kemmler[1], Siegfried Menzel[2], Reinhold Kleiner[1], and Dieter Koelle[1] — [1]Physikalisches Institut - Experimentalphysik II and Center for Collective Quantum Phenomena in LISA$^+$, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany — [2]Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW) Dresden, D-01171 Dresden, Germany

We report on the fabrication and characterization of nanopatterned $YBa_2Cu_3O_7$ (YBCO) SQUIDs with grain boundary junctions (GBJs) for the investigation of small spin systems at 4 K and below. We use photolithography and Ar ion milling to prepattern bridges (several μm

wide) in a YBCO/Au (50 nm/60 nm) bilayer across the grain boundary of a $SrTiO_3$ bicrystal substrate. Subsequently the final SQUID geometry with junction widths down to 80 nm is patterned by focused ion beam (FIB) milling, without significant reduction of critical current density ($j_c > 10^5$ A/cm^2 at 4.2 K) [1]. The Au layer serves as a shunt resistor to provide overdamped GBJs and protects the YBCO during the FIB process. We obtained a flux noise down to $S_\Phi^{1/2} \approx 600\,\mathrm{n}\Phi_0/\mathrm{Hz}^{1/2}$, corresponding to an estimated spin sensitivity $S_\mu^{1/2} \approx 65\,\mu_B/\mathrm{Hz}^{1/2}$

[1] J. Nagel *et al.*, Supercond. Sci. Technol. **24**, 015015 (2011).

TT 33.42 Wed 15:00 Poster B

Wachstumsbedingungen und Eigenschaften von YBCO-Schichten mit Au-Nano Partikeln — •Markus Westerhausen[1], Christian Katzer[1], Romina Diener[1], Ingo Uschmann[2], Frank Schmidl[1], Markus Rettenmayr[3] und Paul Seidel[1] — [1]Friedrich-Schiller-Universität Jena, Institut für Festkörperphysik, Helmholtzweg 5, 07743 Jena, Deutschland — [2]Friedrich-Schiller-Universität Jena, Institut für Optik und Quantenelektronik, Max-Wien-Platz 1, 07743 Jena, Deutschland — [3]Friedrich-Schiller-Universität Jena, Institut für Materialwissenschaft und Werkstofftechnologie, Löbdergraben 32, 07743 Jena, Deutschland

Gegenstand der vorgestellten Untersuchungen ist die Herstellung und Charakterisierung dünner $YBa_2Cu_3O_{7-x}$ (YBCO) Schichten, die unter dem Einfluss von Au-Nanopartikeln auf einkristallinen STO-Substraten aufwachsen. Durch Variation der Beschichtungsparameter der lasergestützten Abscheidung (P(O_2), TS, Laserenergie, Au-Ausgangsschichtdicke, YBCO-Schichtdicke) ist es möglich, sowohl die elektrischen Eigenschaften der YBCO-Schicht als auch die Größe und Verteilung der Au-Partikel zu verändern. Wir stellen strukturelle Untersuchungen (X-Ray, REM, AFM ,TEM) ebenso wie elektrische (J_c, T_c) Messungen an den hergestellten Schichten vor.

TT 33.43 Wed 15:00 Poster B

Grain boundary high-T_c dc-SQUIDs with self-organized nanocrystals — •Stefanie Koch, Peter Michalowski, Christian Katzer, Markus Westerhausen, Frank Schmidl, and Paul Seidel — Friedrich-Schiller-Universität Jena, Institut für Festkörperphysik, Helmholtzweg 5, 07743 Jena, Deutschland

We fabricated and investigated direct current superconducting quantum interference devices (dc-SQUIDs) based on $YBa_2Cu_3O_{7-x}$ (YBCO) grain boundary Josephson junctions. Directed embedding of gold nanoparticles different sizes can modify the crystalline structure and thus the superconducting properties of the YBCO thin films and grain boundaries. We investigated the growth conditions of these particles as well as their influence on the properties of the YBCO thin films. The variation of the size and distribution of the gold nanoparticles changes the electrical properties of the dc-SQUIDs. For this kind of device the normal resistance, critical current density, the resulting I_cR_N-product, the London penetration depth and transfer function are analyzed. Furthermore we will show noise properties for such modified dc-SQUIDs.

TT 33.44 Wed 15:00 Poster B

Characterization of directly coupled $YBa_2Cu_3O_{7-x}$ SQUID magnetometers — •Alexander Guillaume, Verena Beister, Jan M. Scholtyssek, Frank Ludwig und Meinhard Schilling — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Technische Universität Braunschweig, Hans-Sommer-Str. 66, D-38106 Braunschweig, Germany.

Superconducting Quantum Interference Devices (SQUIDs) can be employed as highly sensitive magnetic field sensors in a variety of applications such as magnetoencephalography or magnetic nanoparticle detection. We fabricated SQUIDs from the high-T_c superconductor $YBa_2Cu_3O_{7-x}$ on symmetric $SrTiO_3$-bicrystal substrates by pulsed laser deposition and argon ion etching. The layout consists of two directly coupled magnetometers on one chip which are attached to a rectangular pickup loop.
The measurements were carried out in a liquid nitrogen container using a variable temperature insert. The temperature at the magnetically shielded sample holder can be adjusted between 77 K and 100 K. Here, we present measurements of the I-V-curves under the influence of a magnetic field for different sample temperatures. Also, the influence of the temperature and the influence of the bias current on the V-Φ-curves were investigated. From these measurements, parameters of the SQUID were calculated and compared to the theoretical estimations. Additionally, noise spectra were recorded for different bias reversal frequencies by using a direct-coupled flux-locked loop electronics from Magnicon GmbH.

TT 33.45 Wed 15:00 Poster B

Cooper pair and quasiparticle transport in Josephson junction chains — •Roland Schäfer[2], Andreas Fiebig[1], Birgit Kiessig[2,1], Hannes Rotzinger[1], and Alexey V. Ustinov[1] — [1]Physikalisches Institut, Karlsruhe Institute of Technology — [2]Institut für Festkörperphysik, Karlsruhe Institue of Technology

We present measurements of IV characteristics of daisy-chained mesoscopic SQUID loops where the charging energy is of the same order as the Josephson coupling energy at zero magnetic field. At low voltages the transport is suppressed to a level below the detection limit. Above a threshold V_{sw} the system jumps to a resistive brunch. The effective Josephson coupling along the chain can be modulated by a magnetic field. The field dependence of the IV characteristics gives evidence that the current is carried dominantly by Cooper pairs. Yet, the smooth transition to quasiparticle dominated transport at large bias hints towards a dissipation mechanism that involves generation and incoherent transport of the latter at any finite current even for voltages well bellow $2N\Delta$, where N is the number of Josephson junctions in the chain and Δ is the superconducting energy gap.

TT 33.46 Wed 15:00 Poster B

Fabrication of Flux Qubits and Resonators for their Dispersive Readout — •Anastasia V. Shcherbakova[1], Kirill G. Fedorov[1], Roland Schäfer[2], and Alexey V. Ustinov[1] — [1]Physikalisches Institut and DFG-Centrum für Funktionelle Nanostrukturen (CFN), Karlsruher Institut für Technologie, D-76128 Karlsruhe, Germany — [2]Institut für Festkörperphysik, Karlsruher Institut für Technologie, D-76344 Eggenstein-Leopoldshafen, Germany

The dispersive readout of a superconducting qubit gives the possibility to read it out without damaging the quantum state space. The idea of dispersive readout with the help of a resonator is based on the shift of the resonator frequency depending on the state of the qubit coupled to it. This work is devoted to the fabrication of flux qubits coupled to different types of resonators - linear $\lambda/4$ resonators and non-linear resonators. We will present preliminary results on measurements of superconducting quantum bits in these schemes. We are also concerned with developing a scalable readout scheme using a quantum cavity bus.

TT 33.47 Wed 15:00 Poster B

Influence of mechanical strain on coherent atomic tunneling systems investigated by Josephson phase qubits — •Torben Peichl[1], Grigorij J. Grabovskij[1], Jürgen Lisenfeld[1], Georg Weiss[1,2], and Alexey V. Ustinov[1,2] — [1]Physikalisches Institut, KIT, 76131 Karlsruhe — [2]DFG Centrum für Funktionelle Nanostrukturen, KIT, 76131 Karlsruhe

Forty years ago Zeller and Pohl discovered a fundamental difference of the heat capacity of glassy materials compared to their crystalline counterparts. Only one year later Anderson, Halperin and Varma attributed this behavior to two-level systems (TLSs), which are formed by the two lowest energy states of atoms tunneling in a double-well potential. This idea was the basis for the so-called tunneling model which despite its totally empiric nature proved to be very successful in describing the universal properties of dissordered materials at temperatures below 1 K. — It is believed that those TLSs also present in the thin disordered oxide barrier of Josephon junctions, used e.g. in the design of phase qubits, are the main reason for decoherence and thus limit the lifetime of the macroscopic quantum state.

Here we present a method that for the first time allowed the investigation of individual coherent atomic TLSs. We apply strain by in situ bending the chip with the phase qubits and studying the so-called "avoided-level-crossings" in the qubit spectrum that are caused by the resonant coupling between the phase eigenstates and coherent TLSs. As a result we can extract their properties that are in good agreement with the tunneling model.

TT 33.48 Wed 15:00 Poster B

Comparing coherence time of Josephson junction phase qubits made of different materials — •Kirill Lakhmanskiy[1,2], Jürgen Lisenfeld[2], and Alexey V. Ustinov[2] — [1]Kotel'nikov Institute of Radio Engineering and Electronics, Russian Academy of Sciences, 125009 Moscow, Russia — [2]Physikalisches Institut, Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany

Superconducting phase qubits suffer from energy relaxation which occurs predominantly in the dielectrics used to insulate the qubit junction or to make a shunt capacitor. This is verified from our measurements on phase qubits made using either SiO_x or SiN_x dielectrics. The latter circuits achieve an energy relaxation time T_1 of about 40 ns which is 8 times longer than for the identically made SiO_x circuits. We also plan to explore an alternative idea to replace the lossy tunnel junction by a nanowire, leaving the shunt capacitor unchanged. Such a qubit circuit can be fabricated without junction dielectric and should thus achieve longer coherence times.

TT 33.49 Wed 15:00 Poster B

Charge transport through 1D arrays of small capacitance Josephson junctions — •Jochen Zimmer[1], Andreas Fiebig[1], Roland Schäfer[2], Hannes Rotzinger[1], and Alexey V. Ustinov[1] — [1]Physikalisches Institut, Karlsruhe Institute of Technology — [2]Institut für Festkörperphysik, Karlsruhe Institute of Technology

We investigate one-dimensional arrays of small capacitance Josephson junctions, fabricated by conventional e-beam lithography techniques. These arrays can serve as model systems for the study of superconductor-insulator transitions as found in thin disordered superconducting films. For sufficiently low Josephson energy, the arrays we fabricated exhibit a pronounced Coulomb blockade, i.e. insulating behavior. We studied the transport properties of the arrays in a voltage-bias setup. Data taken at several array lengths and different temperatures in the Coulomb blockade regime and at finite conductance will be presented.

TT 33.50 Wed 15:00 Poster B

Supercurrent in Nb/Au-nanowire/Nb Josephson junctions — •Nick Borgwardt[1,2], Yusuf H. Günel[1,2], Huijun Yao[1,3], Gregor Panaitov[4], Detlev Grützmacher[1,2], and Thomas Schäpers[1,2,5] — [1]Peter Grünberg Institute -9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA-Fundamentals of Future Information Technology — [3]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, People's Republic of China — [4]Peter Grünberg Institute -8, Forschungszentrum Jülich, 52425 Jülich, Germany — [5]II. Physikalisches Institut, RWTH Aachen University,52056 Aachen, Germany

Josephson junctions and SQUIDs were fabricated using single crystalline gold nanowires (NWs), grown by electrochemical deposition. The diameter of the NWs ranged from 80 to 140nm with a length of several μm. Devices with an electrode distance ranging from 80 to 300nm were fabricated by electron beam lithography and subsequent Nb sputtering.

Electrical measurements were carried out in a ^{3}He cryostat at temperatures between 0.3 and 6K. From the current-voltage characteristics of the junctions a critical current as high as I_c 60μA at 0.4K was deduced. Measurements of the critical current depending on temperature and magnetic field give insights into the fundamental transport properties. Analyzing the differential resistance we observed pronounced sub-gap peaks which we assigned to Andreev reflections.

TT 33.51 Wed 15:00 Poster B

Mesoscopic conductance and critical current fluctuations in Nb/InAs-nanowire/Nb Josephson Junctions — Yusuf H. Günel[1,2], •Igor Batov[3], Hilde Hardtdegen[1,2], Kamil Sladek[1,2], Andreas Winden[1,2], Karl Weis[1,2], Gregor Panaitov[4,2], Detlev Grützmacher[1,2], and Thomas Schäpers[1,2,5] — [1]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]JARA - Fundamentals of Future Information Technology — [3]Institute of Solid State Physics, Russian Academy of Sciences, Chernogolovka, 142432 Moscow district, Russia — [4]Peter Grünberg Institut (PGI-8), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [5]II. Physikalisches Institut, RWTH Aachen, 52056 Aachen, Germany

We report on the experimental study of mesoscopic Josephson junctions based on InAs nanowires and niobium superconducting electrodes. The gate voltage and magnetic field dependent measurements revealed pronounced conductance and critical current fluctuations. We found that the pattern of the conductance fluctuations as a function of gate voltage follows precisely the fluctuations of the Josephson critical current. It has been found that the conductance fluctuation amplitude in Nb/InAs-nanowire/Nb samples significantly exceeds the amplitude of the normal-state universal conductance fluctuations (UCF) in the reference samples with normal conducting Au/Ti contacts. We attribute the enhancement of the conductance fluctuations in nanowires contacted with superconductors to the contribution of phase-coherent Andreev reflection.

TT 33.52 Wed 15:00 Poster B

Kritische Stromdichte von Josephson-Kontakten mit NbSi-Barriere in Abhängigkeit von Temperatur, Magnetfeld und Zusammensetzung — •Thomas Scheller, Müller Franz, Wendisch Rüdiger, Kieler Oliver, Störr Kathrin, Weimann Thomas, Egeling Bert und Kohlmann Johannes — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig

Josephson-Kontakte werden u.a. zur Erzeugung von quantengenauen Referenzspannungen eingesetzt. An der PTB werden dazu seit einigen Jahren überdämpfte Josephson-Kontakte mit einer Barriere aus amorphem Nb_xSi_{1-x} eingesetzt. Dieses Material zeigt einen Metall-Halbleiter-Übergang bei x=11,5%. Durch Anpassung der Barrierendicke d und des Niob-Gehaltes x können kritische Stromdichte und charakteristische Spannung des Josephson-Kontaktes nahezu unabhängig voneinander eingestellt werden. Wir haben Kontakte mit Barrierenzusammensetzungen auf beiden Seiten des Metall-Halbleiter-Überganges untersucht und die Abhängigkeit der kritischen Stromdichte von Temperatur und externem Magnetfeld gemessen. Dabei haben wir festgestellt, dass dieser Typ von Josephson-Kontakten je nach Zusammensetzung der Barrieren als Tunnelkontakt oder als weak link arbeitet. Die Magnetfeldabhängigkeit der kritischen Stromdichte zeigt zum Teil deutliche Abweichungen vom Fraunhofer-Muster eines Kontaktes mit homogener Josephson-Stromverteilung.

Teilweise finanziert durch die EU. (ERA-NET Plus, Nr. 217257, JoSy-Projekt).

TT 33.53 Wed 15:00 Poster B

Nb/HfTi/Nb nanoSQUIDs with optimized spin sensitivity — •Matthias Rudolph[1], Roman Wölbing[1], Joachim Nagel[1], Matthias Kemmler[1], Reinhold Kleiner[1], Dieter Koelle[1], Oliver Kieler[2], Thomas Weimann[2], Johannes Kohlmann[2], and Alexander Zorin[2] — [1]Physikalisches Institut and Center for Collective Quantum Phenomena in LISA$^+$, Universität Tübingen, 72076 Tübingen, Germany — [2]Fachbereich 2.4 , Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany

Nowadays the downscaling of SQUIDs to the submicron range is mainly motivated by applications for magnetization measurements of small magnetic systems like single magnetic molecules. We use SQUIDs based on Nb/HfTi/Nb junctions, which do not require bulky resistive shunts. The parameters of the junctions can be optimized for flux sensitive SQUIDs and the used nanolithography technique (e-beam) allows the realization of SQUID loops in the submicron range and junction sizes on the order of 100 nm. For some SQUIDs we implemented coils on the chip that are galvanically coupled to the SQUID loop. These coils allow to modulate the SQUIDs without the need of external coils with relatively small currents. This might be useful for the flux-locked operation of our SQUIDs using conventional SQUID electronics.

We present a detailed study of the transport properties and the flux noise characteristics of several SQUIDs with different designs (magnetometer-type or gradiometric) in low magnetic fields as well as magnetic fields up to 100 mT. For our best SQUID geometries we obtain a spin sensitivity $S_\mu^{1/2} = 29\,\mu_B/\mathrm{Hz}^{1/2}$.

TT 33.54 Wed 15:00 Poster B

Nonequilibrium Josephson and quasi-particle currents through hybrid superconductor-quantum dot devices — •Sascha Ratz and Milena Grifoni — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

We present a real-time diagrammatic theory for investigating the Josephson current through an interacting quantum dot coupled to two biased superconducting leads showing a phase difference Φ. Our nonequilibrium transport theory is based on the time evolution of the reduced density matrix obtained by integrating out the fermionic degrees of freedom in the leads. As an example we study a system described as a single-level Anderson impurity model in a two-terminal transistor geometry in the weak coupling regime. Here we investigate the interplay between quasiparticle cotunneling current and phase-driven Cooper-pair tunneling in second order in the tunnel-coupling strength Γ as well as in the limit of large superconducting gaps in the leads.

TT 33.55 Wed 15:00 Poster B

Transport through Andreev bound states in a triplet super-

conductor - ferromagnet - singlet superconductor Josephson junction — •Wei Chen[1], Philip M. R. Brydon[2], Yasuhiro Asano[3], and Dirk Manske[1] — [1]Max-Planck-Institut für Festkörperforschung, D-70569 Stuttgart — [2]Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden — [3]Department of Applied Physics, Hokkaido University, Sapporo, 060-8628, Japan

We use microscopic Bogoliubov-de Gennes theory to study a model triplet superconductor - ferromagnet - singlet superconductor Josephson junction. We obtain analytic expressions for the Andreev bound state spectrum, and hence calculate the free energy minimum of the junction, and the spontaneous charge and spin currents. We find that these properties of the junction strongly depend upon the orbital pairing state of the two superconductors. The results are interpreted with the assistance of a tunneling Hamiltonian theory.

TT 33.56 Wed 15:00 Poster B

Proximity effects at the interface between chiral p-wave superconductors and ferromagnets — •Damien Terrade[1], Mario Cuoco[2], Paola Gentile[2], and Dirk Manske[1] — [1]Max Planck Institute For Solid State Research, Stuttgart, Germany — [2]CNR-SPIN, Fisciano (Salerno), Italy

We focus on an interface along the (001) direction. The system is made by a stack of two-dimensional layers, with a $\vec{d}$-vector perpendicular to the plane, which should be the first experimental configuration of the predicted Josephson junctions involving component like Sr_2RuO_4. The SC is described with an extended Hubbard model and the ferromagnetism is based either on a Stoner-like model [1,2] or on a change in the relative bandwidth of electrons for the two different spin polarizations[3]. We compute self-consistently the pairing potentials, the magnetization and the free energy as a function of the exchange field strength as well as the angle between the exchange field and the $\vec{d}$-vector. We have generalized the work done in [3] by including spin-flip process and magnetic impurities at the interface as well as a temperature dependence. We obtain in the FM layers no induced singlet components unlike interface along the (100) direction and strongly reduced oscillations for the triplet components.

[1] K. Kuboki. J. Phys. Soc. Jap. **70**, 9 (2001).
[2] B. M.Andersen, *et al.* Phys. Rev. B **77**, 054501 (2008).
[3] M. Cuoco, *et al.* Phys. Rev. B **78**, 054503 (2008).

TT 33.57 Wed 15:00 Poster B

Josephson-like spin current in junctions composed of antiferromagnets and ferromagnets — •Andreas Moor, Anatoly Volkov, and Konstantin Efetov — Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44780 Bochum, Germany

We study Josephson-like junctions formed by materials with antiferromagnetic (AF) order parameters. As an antiferromagnet, we consider a two-band material in which a spin density wave (SDW) arises, e.g., the Fe-based pnictides in the temperature interval $T_c \leq T \leq T_N$, where T_c and T_N are the critical temperatures for the superconducting (S) and antiferromagnetic transitions, respectively. We have generalized the theory of quasiclassical Green's functions to two-band superconductors, in which superconducting and antiferromagnetic ordering may coexist, and derived the equations for the quasiclassical Green's functions. Especially, we are interested in the Josephson-like spin current in the AF/F/AF (F means a ferromagnet) structures, where the short- and long-range components can be identified. This is an analogy with the case of the Josephson current in an S/F/S junction with a non-homogeneous magnetization where short- and long-range condensate components are induced in the F-layer. However, the analogy is not complete due to the fact that the spin current in AF/F/AF junctions is not constant in space, but oscillates in the ballistic F-layer.

[1] A. Moor, A. F. Volkov, and K. B. Efetov, Phys. Rev. B **83**, 134524 (2011);
[2] A. M., A. F. V., and K. B. E., arXiv:1111.5582;
[3] F. S. Bergeret, A. F. Volkov, K. B. Efetov, Rev. Mod. Phys. **77**, 1321 (2005);
[4] M. Eschrig, Physics Today, **64**, 43 (2011).

TT 33.58 Wed 15:00 Poster B

AC Josephson current through quantum dots — •Bastian Hiltscher[1], Michele Governale[2], and Jürgen König[1] — [1]Theoretische Physik, Universität Duisburg-Essen and CeNIDE — [2]School of Chemical and Physical Sciences and MacDiarmid Institute for Advanced Materials and Nanotechnology, Victoria University of Wellington

We consider a setup consisting of two superconductors linked by a single-level quantum dot with strong Coulomb repulsion. An AC Josephson current is generated by applying a bias voltage to the superconductors. Our formalism bases on a diagramatic perturbation expansion in tunnel coupling [1], where the quasiparticle states are traced out from the total density matrix and the quantum dot as well as the Cooper pair condensates are treated explicitly. The Coulomb repulsion is taken into account nonperturbatively. We find that the first harmonic dominates the higher ones. Furthermore, we discuss the differences between the AC and the DC Josephson effect.

[1] M. Governale, M. G. Pala, and J. König, PRB 77, 134513 (2008).

TT 33.59 Wed 15:00 Poster B

Influence of finite superconducting gaps on the proximity effect in interacting quantum dots — •David Futterer[1], Jacek Swiebodzinski[1], Michele Governale[2], and Jürgen König[1] — [1]Theoretische Physik, Universität Duisburg Essen and CeNIDE, 47048 Duisburg, Germany — [2]School of Chemical and Physical Sciences and MacDiarmid Institute for Advanced Materials and Nanotechnology, Victoria University of Wellington, PO Box 600, Wellington, New Zealand

The tunnel coupling of superconductors to an interacting quantum dot leads to the formation of Andreev-bound states (ABS), which are the excitation energies of the proximized dot. In the limit of large superconducting gaps in the leads, $\Delta \to \infty$, the hybrid system of dot and superconductors can be described exactly by an effective Hamiltonian.

Since in real systems the superconducting gap is usually not a large quantity it is an interesting question whether the predictions of the $\Delta \to \infty$ calculations still have significance for real systems with finite gaps. In order to investigate this question we perform two different calculations: first, a systematic $1/\Delta$ expansion where we find that the occurring currents show only small changes but we find indications that a finite Δ renormalizes the ABSs. To quantify the last statement we perform a second calculation where we resum the coupling to the superconductors at arbitrary values for Δ neglecting vertex corrections.

TT 33.60 Wed 15:00 Poster B

Josephson current through a quantum dot coupled to a nanomagnet — •Pascal Stadler, Cecilia Holmqvist, and Wolfgang Belzig — Fachbereich Physik, Universität Konstanz, D-78457 Konstanz, Germany

Magnetically tunable nanoscale Josephson junctions have recently drawn increased attention since they offer interesting perspectives for superconducting spintronics [1]. We theoretically study the transport through a junction consisting of two superconducting electrodes and a quantum dot which is coupled to a nanomagnet. A magnetic field applied to the central region lifts the spin degeneracy of the energy levels on the dot and starts a precession of the nanomagnet's magnetization with the Larmor frequency. This precession induces spin flips as well as a renormalization of the Zeeman splitting on the dot. The transport properties are calculated using a non-equilibrium Green's function approach. We show how the density of states on the dot is modified due to the nanomagnet and present the results for the current-phase relation. The current can be either suppressed or enhanced depending on the precession frequency, the coupling strength and the angle between the direction of the nanomagnet's magnetization and the magnetic field. Tuning the precession frequency can also cause the junction to undergo a 0 to π transition.

[1] C. Holmqvist, S. Teber, and M. Fogelström, Phys. Rev. B **83**, 104521 (2011)

TT 33.61 Wed 15:00 Poster B

Multiply gapped density of states in a normal metal in contact with a superconductor — •Johannes Reutlinger[1], Yuli V. Nazarov[2], Leonid I. Glazman[3], and Wolfgang Belzig[1] — [1]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [2]Kavli Institute of Nanoscience Delft, Delft University of Technology, 2628 CJ Delft, Netherlands — [3]Department of Physics, Yale University, New Haven CT 06511-8499, USA

The spectral properties of a normal metal adjacent to a superconductor are strongly dependent on the characteristic mesoscopic energy scale - the Thouless energy E_{Th} - and the strength of the connection. In this work, we predict that the local density of states (LDOS), besides the well know minigap $\sim E_{Th}$, can exhibit a multiple gap structure, which strongly depends on the type of the contact. For ballistic contacts we calculate these secondary gaps analytically in the framework of quantum circuit theory of mesoscopic transport. The secondary

gaps are absent in the case of tunnel contacts. In the general case the equations are solved numerically for more realistic contacts, like for example diffusive connectors or dirty interfaces, which are characterized by continuous distributions of transmission eigenvalues between 0 and 1. We find that the gap vanishes in these cases, but the density of states is still suppressed around the superconducting gap edge. Distribution functions with a stronger weight at higher transmissions can be modeled through asymmetric ballistic double junctions, which even exhibit multiple gaps. Such spectral signatures are fundamental to disordered nanoscopic conductors and experimentally accessible.

TT 33.62 Wed 15:00 Poster B

Long-range spin transport in superconductors — •Detlef Beckmann[1], Florian Hübler[2], Michael J. Wolf[1], and Hilbert von Löhneysen[2,3] — [1]Institut für Nanotechnologie, Karlsruher Institut für Technologie — [2]Institut für Festkörperphysik, Karlsruher Institut für Technologie — [3]Physikalisches Institut, Karlsruher Institut für Technologie

Recently, there has been some controversy about spin-polarized quasiparticle transport and relaxation in superconductors, with reports of both anomalously short [1] or anomalously long [2] relaxation times as compared to the normal state. Here, we report on non-local transport in multiterminal superconductor-ferromagnet structures. We find signatures of spin transport over distances much larger than the normal-state spin-diffusion length in the presence of a large Zeeman splitting of the quasiparticle states. The relaxation length shows a nearly linear increase with magnetic field, hinting at a freeze-out of spin relaxation by the Zeeman splitting.

[1] Poli et al., Phys. Rev. Lett. **100**, 136601 (2008)
[2] Yang et al., Nature Materials **9**, 586 (2010)

TT 33.63 Wed 15:00 Poster B

Proximity effect between a ferromagnetic insulator and a superconductor — •Michael J. Wolf[1], Florian Hübler[1,2], Christoph Sürgers[3], Detlef Beckmann[1], and Hilbert v. Löhneysen[2,3] — [1]Institut für Nanotechnologie, KIT — [2]Institut für Festkörperphysik, KIT — [3]Physikalisches Institut, KIT

Electron transfer through spin-active interfaces can be modeled by the transmission amplitudes and a relative phase shift between spin-up and spin-down wavefunctions, the spin-mixing angle [1]. Recently, Andreev bound states have been observed in F/S tunnel contacts which imply a non-zero spin-mixing angle of the ultrathin F/S barrier [2]. In order to separate the spin-active interface from the detector tunnel contact, we have fabricated normal metal / superconductor tunnel contacts on top of a ferromagnetic insulator. We prepared EuS thin films (d $\approx$ 20 nm) on top of Si(111) substrates by means of e-beam evaporation and created Al / Al-Oxide / Cu tunnel contacts by means of shadow evaporation. In an applied magnetic field, the tunnel spectra show an enhanced Zeeman splitting which is due to the presence of the exchange field of the EuS layer [3]. Furthermore, we observe small peaks in the subgap region of the tunnel spectra which may be attributed to Andreev bound states due to a non-zero spin-mixing angle at the EuS / Al interface. The results suggest the use of EuS thin films for generating equal-spin triplet superconductivity.

[1] T.Tokayasu *et al.* Phys. Rev. B **38**, 8823 (1988)
[2] F. Hübler *et al.* arXiv:1012.3867 (2010)
[3] X. Hao *et al.* Phys. Rev. Lett. **67**, 1342 (1991)

TT 33.64 Wed 15:00 Poster B

Ferromagnet/superconductor hybrids with out-of-plane magnetization: comparison of current-in-plane and current-out-of-plane measurements — •Richard Montbrun[1], Christoph Sürgers[1], and Hilbert v. Löhneysen[1,2] — [1]Karlsruhe Institute of Technology, Physikalisches Institut and Center for Functional Nanostructures, D-76049 Karlsruhe — [2]Karlsruhe Institute of Technology, Institut für Festkörperphysik, D-76021 Karlsruhe

Ferromagnet (F)/superconductor (S)/F hybrid structures - with S = Nb and Co/Pt multilayers as F electrodes - were fabricated by e-beam lithography and reactive ion-etching using silicon-nitride shadow masks on Si/SiO_2. The sample layout allows four-point resistivity measurements with the current perpendicular to the F/S interface. In addition, planar F/S/F multilayers were prepared for current-in-plane measurements. The dependence of the superconductive transition temperature T_c on the relative orientation of the two F-layer magnetizations (parallel or antiparallel) was investigated for different S-layer thicknesses and transport currents. For current out of the plane T_c is always higher in the antiparallel configuration than in the parallel configuration whereas for current in the plane we observe a peculiar influence of the transport current amplitude on the spin-switch behavior. This indicates a different pair breaking in the two layouts.

TT 33.65 Wed 15:00 Poster B

Long-range triplet pairing in superconductor-ferromagnet proximity effect heterostructures — •V. Zdravkov[1,2], J. Kehrle[1], G. Obermeier[1], D. Lenk[1], H.-A. Krug von Nidda[1], C. Müller[1], M.Yu. Kupriyanov[3], A.S. Sidorenko[2], S. Horn[1], R. Tidecks[1], and L.R. Tagirov[1,4] — [1]Institut für Physik, Universität Augsburg, D-86159 Augsburg, Germany — [2]Institute of Electronic Engineering and Nanotechnologies ASM, Kishinev MD-2028, Moldova — [3]Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow 119992, Russia — [4]Solid State Physics Department, Kazan Federal University, 420008 Kazan, Russia

For superconductor-ferromagnet (S-F) heterostructures with two or more F-layers, the generation of a long-range, odd-in-frequency triplet pairing at non-collinear (NOC) alignment of the F-layers magnetizations is predicted [1]. Here, we report on the first experimental observation of the triplet pairing in a $Nb/Cu_{41}Ni_{59}/Nb/Co/CoO_x$ spin-valve type proximity effect heterostructure, where a very thin Nb layer between the F materials acts as a normal conducting spacer. Measuring the resistance of the samples as a function of an external magnetic field, we observed a sequence of transitions through normal conducting (NC) and superconducting (SC) phases, when the system goes along the magnetic hysteresis loop. The scenario found during the NOC regime is consistent with the theoretical picture of the singlet superconductivity suppression by the long-range triplet pairing generation [2].

[1] F.S. Bergeret, et al. Rev. Mod. Phys. 77, 1321 (2005).
[2] Ya.V. Fominov, et al. JETP Lett. 91, 308 (2010).

TT 33.66 Wed 15:00 Poster B

Development of a large-area detector for position and energy resolving detection of molecular fragments — •Alexandra Kampkötter, Andreas Fleischmann, Loredana Gastaldo, Sebastian Kempf, Andreas Pabinger, Christian Pies, Sönke Schäfer, Thomas Wolf, and Christian Enss — Kirchhoff-Institut für Physik, INF 227, 69120 Heidelberg

The recombination of a molecular cation with an electron, followed by fragmentation, is a fundamental reaction in cold, dilute plasmas and plays a key role in interstellar chemistry. To investigate such reactions in laboratory environment with full quantum control, the Max-Planck Institute for Nuclear Physics in Heidelberg is building a cryogenic storage ring to prepare molecular ions in their groundstate. The full kinematics of these recombination processes can be resolved by a position and energy sensitive detection of the reaction products/molecule fragments. We describe the development of a new large-area MMC for position sensitive detection of massive particles with kinetic energies down to a few keV. The detector encompasses sixteen pie-shaped large-area absorbers to form a circular whole with a diameter of 36mm. The temperature sensor is positioned on the outer edge of each absorber. The rise-time of the detector signals varies with the impact location of the particle due to diffusive expansion of heat in the absorbers. We present results of first test measurements where energy was deposited in the absorber at different positions by light pulses from three LEDs. The observed position dependence of the signal shapes agrees well with the one expected from detailed thermal simulations.

TT 33.67 Wed 15:00 Poster B

Low temperature particle detectors with magnetic penetration thermometers — •N. Foerster, D. Hengstler, A. Kampkötter, S. Kempf, C. Pies, G. Pizzigoni, P. Ranitzsch, S. Schäfer, S. Uhl, L. Gastaldo, A. Fleischmann, and C. Enss — Kirchhoff-Institut für Physik, INF 227, 69120 Heidelberg

We present low temperature micro-calorimeters based on a novel sensor concept, the Magnetic Penetration Thermometers (MPTs). The MPTs make use of the temperature dependence of the critical magnetic field and the penetration depth of a superconducting sensor. The superconducting sensor is inductively coupled to a superconducting pick-up coil which also provides a bias magnetic field. The flux in the pick-up coil depends on the position of the interface between normal and superconducting regions in the sensor which in turn is a steep function of temperature. The change of magnetic flux upon the absorption of a particle is read-out by low-noise high-bandwidth dc-SQUIDs. Similar to metallic magnetic calorimeters, MPTs operate in a wide range of temperature and without intrinsic bias power dissipation.

We present the results of numerical simulations for the signal size and energy resolution for various superconducting films based on a simple thermo-dynamical model, as well as first experimental results.

TT 33.68 Wed 15:00 Poster B

Study of the Energy Thermalisation in Superconducting Absorbers by Means of Low Temperature Magnetic Calorimeters — •Daniel Hengstler, Philipp C.-O. Ranitzsch, Jan-Patrick Porst, Loredana Gastaldo, Andreas Fleischmann, and Christian Enss — Kirchhoff Institute for Physics, Heidelberg University INF 227, 69120 Heidelberg, Germany

The use of superconducting particle absorbers for low temperature micro-calorimeters promises several advantages like the possibility to combine high stopping power with low heat capacity. Due to the still not well understood thermalization of the energy released by the interacting particle, superconducting absorbers are used only in special cases. We investigated by means of metallic magnetic calorimeters the temperature response of the paramagnetic sensor following the absorption of an x-ray in a superconducting absorber. We analyzed the pulse shape as function of temperature for different absorber materials: rhenium, aluminum and aluminum doped with 600ppm manganese, zinc and zinc doped with 24ppm Mn. The doping with manganese was performed in order to understand the role of magnetic impurities in the thermalization of energy. We discuss the temperature dependence of the energy thermalization in superconducting absorbers at the light of presently available theories.

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A high-resolution mK-calorimeter applying SQUID-thermometry — •Andreas Reifenberger, Norman Leps, Andreas Fleischmann, Christian Pies, Christian Enss, and Rüdiger Klingeler — Kirchhoff-Institut für Physik, Universität Heidelberg, INF 227,69120 Heidelberg, Germany

A new calorimeter for measuring single-crystalline samples of mg-size at ultra-low temperatures is described. Thermometry is done by means of a paramagnetic sensor material (Er-doped Au) in a low magnetic field. A temperature change results in a magnetization change which can be read out as change in magnetic flux by a superconducting quantum interference device (SQUID). This enables measurements in a wide temperature range (theoretically from 1 mK - 1 K) with very high sensitivities. The bolometric design exhibits low addenda heat capacity and allows measurements of heat capacities from nJ/K to μJ/K by means of a temperature-relaxation method. The performance of the device is compared to a commercially available Quantum Design calorimeter in elsewise unchanged experimental settings in the temperature range from 15 mK to 500 mK.

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A Low-Temperature Scanning Polarizing Microscope for Magneto-Optical Imaging — •Matthias Grünzweig, Stefan Guénon, Matthias Kemmler, Reinhold Kleiner, and Dieter Koelle — Physikalisches Institut and Center for Collective Quantum Phenomena in LISA$^+$, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

We present the design and preliminary results on the performance of a low-temperature scanning polarizing microscope (LTSPM), which has been developed for research on thin film devices based on ferromagnets (F), superconductors (S) and S-F-hybrid structures. The LTSPM is based on confocal laser microscopy for imaging at temperatures from 4 K to 300 K in magnetic fields up to 0.5 T (in plane) and 5 T (out-of-plane). The LTSPM allows to combine imaging of electrical transport properties (via beam-induced voltage change) with imaging of magnetic structures (via Kerr-/Faraday-effect).

The LTSPM can be applied to research on a broad variety of devices, such as Kerr microscopy on ferromagnetic thin film structures, e.g. magnetic tunnel junctions or S-F heterostructures. Using a magneto-optical sensor layer (e.g. EuSe or an Fe-garnet single crystal) for imaging the magnetic stray field above the sample, the LTSPM shall be used for the investigation of vortex distributions in type-II superconductor thin film devices.

TT 33.71 Wed 15:00 Poster B

Modulated Intensity Spin Echo: μeV resolution for dynamics in magnetic samples — •Georg Brandl[1,2], Robert Georgii[2], Wolfgang Häussler[2], and Peter Böni[1] — [1]Physik Department E21, Technische Universität München, D-85748 Garching — [2]Forschungsneutronenquelle Heinz Maier-Leibnitz, Technische Universität München, D-85748 Garching

The MIEZE technique (Modulation of IntEnsity by Zero Effort) [1,2] is a variant of the neutron spin echo technique [3] that achieves the same very high energy resolution by converting a neutron spin oscillation into a high-frequency modulation of the neutron beam. Because all beam preparation is done before the sample, MIEZE is well suited to measuring magnetic samples, even in high magnetic fields, both of which are unfavorable conditions for measurements with conventional neutron spin echo. Here, an introduction is given to the MIEZE principle and presents setup and measurements performed with MIEZE in magnetic fields, both at the FRM II in Munich [4] and at the HFIR in Oak Ridge [5]. Also discussed is the design of a drop-in MIEZE module that can be added to existing neutron instruments.

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TT 33.72 Wed 15:00 Poster B

Coherent broadband THz spectrometer using photomixers for accurate determination of complex dielectric function — •Malte Langenbach[1], Komalavalli Thirunavukkuarasu[1], Holger Schmitz[1], Ernesto Vidal[1], Jennifer Marx[1], Iván Cámara Mayorga[2], Rolf Güsten[2], Axel Roggenbuck[3], Anselm Deninger[3], Joachim Hemberger[1], and Markus Grüninger[1] — [1]II. Physikalisches Institut, Universität zu Köln, Köln, Germany; — [2]Max-Planck-Institut für Radioastronomie, Bonn, Germany; — [3]Toptica Photonics AG, Gräfelfing, Germany

We report on a novel cw THz spectrometer for measurements in high magnetic fields and at low temperatures. The spectrometer employs photomixing of two NIR lasers for generation and phase-sensitive detection of THz radiation from 60 GHz to 1.8 THz. A fast phase-modulation technique using two fiber stretchers is used to determine the amplitude and the phase at a given frequency with excellent reliability. The phase accuracy is increased with further implementation of a third laser which enables correction of phase drifts mainly caused by thermal drifts. Thus, the complex dielectric function can be determined very accurately with a very high resolution in the MHz range. This compact spectrometer in combination with the magneto-cryostat allows for investigations in magnetic fields up to 8 T and temperatures down to 3 K with excellent reliability. Various aspects of the above-mentioned developments will be outlined.

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Broadband dielectric spectroscopy on transition metal oxides: Is $LuFe_2O_4$ ferroelectric? — •Daniel Niermann[1], Joost de Groot[2], Manuel Angst[2], and Joachim Hemberger[1] — [1]II. Physikalisches Institut, Universität zu Köln, 50937 Köln — [2]Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

The mixed valence system $LuFe_2O_4$ was proposed to show a novel type of ferroelectricity based on charge order within triangular Fe-O-double layers at 330 K [1]. However, an unambiguous evidence for ferroelectricity by means of dielectric polarization measurement, e.g. hysteretical P-E-loops, is difficult to give due to the relatively high residual conductivity in this material. We show results of temperature-dependent dielectric measurements on the potentially multiferroic material $LuFe_2O_4$ in a broad frequency range from mHz to GHz. Our measurements on a singlecrystalline sample [2] show very high magnitudes of both real and imaginary part of complex permittivity, decreasing towards low temperatures and high frequencies according to those reported in literature [1]. However in the temperature range from 200 - 400 K this dispersive behaviour is well-described by a standard equivalent-circuit model considering Maxwell-Wagner-type contacts and variable range hopping AC-conductivity, without a pronounced contribution of intrinsic dipolar polarization and thus the ferroelectric character of the charge order in $LuFe_2O_4$ has to be questioned. (*Work supported by DFG through SFB 608.*

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TT 33.74 Wed 15:00 Poster B

High-magnetic-field investigation of $CoCr_2O_4$ — •A. V. Pronin[1], M. Uhlarz[1], R. Beyer[1], T. Fischer[1], J. Wosnitza[1],

B. P. Gorshunov[2,3,4], G. A. Komandin[2], A. S. Prokhorov[2,3], M. Dressel[4], A. A. Bush[5], and V. I. Torgashev[6] — [1]Hochfeld-Magnetlabor Dresden, Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]A. M. Prokhorov Institute of General Physics, Russian Academy of Sciences, Moscow, Russia — [3]Moscow Institute of Physics and Technology (State University), Russia — [4]1. Physikalisches Institut, Universität Stuttgart, Germany — [5]Moscow Institute of Radiotechnics, Electronics, and Automation, Russia — [6]Faculty of Physics, Southern Federal University, Rostov-on-Don, Russia

We report on magnetic, optical, and thermodynamic properties of multiferroic $CoCr_2O_4$ in magnetic fields up to 14 T. We have found indications of a new phase transition at $T^* = 5 - 6$ K. The phase between T^* and the lock-in transition at 15 K is characterized by magnetic irreversibility. At higher fields the irreversibility increases. Heat-capacity measurements confirm the transition at T^*, and also show the irreversible behaviour. We construct a field-temperature phase diagram of $CoCr_2O_4$. Below the ferrimagnetic transition (94 K), the low-frequency (terahertz) optical response is dominated by a magnetic exchange mode, which shows an anomalous temperature dependence and a softening at the structural transition (26 K).

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