# TT 32: Postersession Superconductivity: Josephson Junctions, SQUIDs, Heterostructures, Andreev Scattering, Vortex Physics, Cryodetectors, Measuring Devices, Cryotechnique

Time: Wednesday 14:00–18:00 Location: P1A

TT 32.1 Wed 14:00 P1A

**Investigation of self-heating in $Bi_2Sr_2CaCu_2O_8$ single crystals via low-temperature scanning laser microscopy** — •M. Grünzweig[1], S. Guénon[1], H. B. Wang[2], J. Yuan[2], A. Iishi[2], S. Arisawa[2], T. Hatano[2], T. Yamashita[2], D. Koelle[1], and R. Kleiner[1] — [1]Physikalisches Institut &Center for Collective Quantum Phenomena,Universität Tübingen,Germany — [2]National Institute for Materials Science,Tsukuba 3050047, Japan

Recently, relatively strong emission of Terahertz radiation by large stacks of intrinsic Josephson junctions in $Bi_2Sr_2CaCu_2O_8$ single crystals has been discovered [1]. Perhaps surprisingly, the radiation occurs at dc input power levels where Joule heating already changes the temperature distribution in the sample considerably and thus affects the electric properties of the sample. To investigate this we have used low-temperature scanning laser microscopy (LTSLM) to image local electric field distributions in the stacks [2]. For high bias currents we discovered a feature that can be interpreted as a hot spot (i. e. an area of the stack which temperature is above the critical temperature of the superconductor). The fact that the hot spot is accompanied by a standing wave pattern is an indication that the hot spot might play an important role to stimulate Terahertz radiation. We present LTSLM results obtained from stacks with different geometries and with different current injection.

[1] L. Ozyuzer *et al.*, Science **318**, 1291 (2007)
[2] H. B. Wang, S. Guénon *et al.*, submitted to Phys. Rev. Lett.; arXiv:0807.2749v1 [cond-mat.supr-con]

TT 32.2 Wed 14:00 P1A

**$YBa_2Cu_3O_7$ grain boundary junction dc SQUIDs for operation in high magnetic fields** — •Konstantin Konovalenko, Joachim Nagel, Markus Turad, Matthias Bailer, Matthias Grünzweig, Reinhold Kleiner, and Dieter Koelle — Physikalisches Institut &Center for Collective Quantum Phenomena,Universität Tübingen,Germany

We investigate the suitability of dc SQUIDs for operation in high magnetic fields at 4.2 K. For this purpose, we fabricated small (micron-sized) $YBa_2Cu_3O_7$(YBCO) grain boundary junction dc SQUIDs on $SrTiO_3$ bicrystals with thin film Au shunt resistors. Fabrication was done by pulsed laser deposition of YBCO films, in-situ deposition of electron-beam evaporated Au films and Ar ion milling with photolithographically defined masks. For the fabricated SQUIDs we present results on electric transport properties, measured in a four-point arrangement, and on noise properties, measured with a Nb dc SQUID amplifier.

TT 32.3 Wed 14:00 P1A

**Ramp-type Josephson junctions with $YBa_2Cu_3O_7$ and Nb electrodes** — •Andreas Blank, Markus Turad, Christoph Maurer, Christoph Back, Reinhold Kleiner, and Dieter Koelle — PhysikalischesInstitut & Center for Collective Quantum Phenomena, UniversitätTübingen, Germany

We present our status of the development of an improved ramp-type Josephson junction technology for fabrication of all-high $T_c$ junctions with $YBa_2Cu_3O_7$ (YBCO) electrodes and $PbBa_2Cu_3O_7$ (PBCO) barrier, and hybrid YBCO/Au/Nb junctions. The fabrication is done in a UHV cluster tool for the deposition of oxide thin films by pulsed laser deposition (PLD) using in-situ high-pressure RHEED for monitoring the thin film growth. Deposition of Nb and Au thin films is done by dc magnetron sputtering and electron beam evaporation, respectively, in two separate processing chambers. A milling chamber equipped with a high-frequency inductively-coupled plasma source allows surface cleaning and etching with argon and/or oxygen, reactive ion etching with $SF_6$ and removal of resist structures in an oxygen plasma. The substrate holder in the milling chamber allows in-situ adjustment and variation of the milling angle and additional rotation of the substrate about its normal axis, in order to realize an isotropic milling process, which is essential for the fabrication of 2-dimensional arrays of Josephson junctions. Initial results on the properties of fabricated ramp junctions will be shown.

TT 32.4 Wed 14:00 P1A

**Thermal and Quantum Escape of Fractional Josephson Vortices** — •Hanna Pöhler[1], Uta Kienzle[1], Kai Buckenmaier[1], Tobias Gaber[1], Michael Siegel[2], Dieter Koelle[1], Reinhold Kleiner[1], and Edward Goldobin[1] — [1]Physikalisches Institut, Center for Collective Quantum Phenomena, Universität Tübingen, Germany — [2]Institut für Mikro- und Nanoelektronische Systeme, Universität Karlsruhe (KIT), Germany

By using a pair of tiny current injectors one can create an arbitrary $\kappa$ discontinuity of the phase in a long Josephson junction (LJJ) and a fractional Josephson vortex (FJV), carrying a fraction $\Phi/\Phi_0 = \kappa/2\pi \leq 1$ of the magnetic flux quantum $\Phi_0 \approx 2.07 \cdot 10^{-15}$ Wb, which is pinned at the discontinuity [1]. If a bias current $I$, exceeds the critical value $I_c(\kappa)$ [2,3], an integer fluxon is torn off the discontinuity and the LJJ switches to the voltage state. Due to thermal or quantum fluctuations this escape event may occur at $I \lesssim I_c(\kappa)$.[4]

We have measured the critical current distribution $P(I)$ for different values of $\kappa$, temperature $T$ and junction geometry. At low temperatures we see a saturation of the distribution width which is presumably due to the crossover from thermal activation to quantum tunnelling. The results are compared to numerical simulations based on the static sine-Gordon equation.

[1] E. Goldobin, et al., Phys. Rev. B **70**, 174519 (2004).
[2] A. V. Ustinov, Appl. Phys. Lett. **80**, 3153 (2002).
[3] B. A. Malomed and A. V. Ustinov, Phys. Rev. B **69**, 64502 (2004).
[4] P. Hänggi, et al., Rev. Mod. Phys. **62**, 251 (1990)

TT 32.5 Wed 14:00 P1A

**A Josephson Vortex Ratchet climbs uphill** — •Martin Knufinke[1], Kai Buckenmaier[1], Michael Siegel[2], Dieter Koelle[1], Reinhold Kleiner[1], and Edward Goldobin[1] — [1]Physikalisches Institut – Center for Collective Quantum Phenomena, University of Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany — [2]Institut für Mikro- und Nanoelektronische Systeme, Universität Karlsruhe (KIT), Hertzstr. 16, D-76187 Karlsruhe, Germany

A particle in a potential with broken reflection symmetry has a preferential direction of motion being driven by a deterministic or stochastic force with zero time-average [1]. Josephson vortex ratchets (JVRs) offer a flexible way of implementing such a system in the underdamped regime [2]. In a long annular Josephson junction the particle is a fluxon that moves in a potential created by a suitable current injection profile [3,4]. Due to the asymmetry of the resulting potential an ac current drive leads to a dc voltage across the Josephson junction.

Being in the rectification regime we apply an additional bias current which tilts the potential and pushes the fluxon in the direction opposite to its motion, i.e. the fluxon moves uphill due to the ratchet effect. At some value $I_{\rm stop}$ of bias the fluxon stops. We determine $I_{\rm stop}$ both experimentally and numerically and obtain information about the loading capability of the ratchet.

[1] P. Hänggi *et al.*, Ann. Phys. (Leipzig) **14**, 51 (2004)
[2] G. Carapella *et al.*, Phys. Rev. Lett. **87**, 077002 (2001)
[3] E. Goldobin *et al.*, Phys. Rev. E **63**, 031111 (2001)
[4] M. Beck *et al.*, Phys. Rev. Lett. **95**, 090603 (2005)

TT 32.6 Wed 14:00 P1A

**Effect of magnetic field on the escape rate in small Josephson junctions** — •Kirill Fedorov[1], Alexey Feofanov[1], Ralf Dolata[2], Brigitte Mackrodt[2], and Alexey Ustinov[1] — [1]Physikalisches Institut, Universität Karlsruhe (TH), 76131 Karlsruhe, Germany — [2]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany

The escape of a point-like Josephson junction (JJ) from the superconducting state is reduced to the escape of a particle from a metastable state in the washboard potential. In the case of a finite size JJ, this problem becomes considerably more complex since the phase acquires a spatial dependence. We experimentally study the macroscopic quantum tunneling (MQT) and the thermal escape in a JJ, placed in an externally applied magnetic field and compare results with the recent theoretical paper by Yu. N. Ovchinnikov et al. [1]. It has been theoretically predicted that the magnetic field strongly changes the crossover temperature between MQT and thermal escape. The experiments were

performed using 5 x 3 $\mu m^2$ niobium JJs with critical current density 1 $kA/cm^2$. We have found peculiarities in the escape statistics near the minima of Fraunhofer pattern of the switching current dependence on a magnetic field. A comparison of our experimental results with the Ovchinnikov et al. theory will be presented.

[1] Y. N. Ovchinnikov, A. Barone, and A. A. Varlamov, Phys. Rev. Lett. **99**, 037004 (2007).

TT 32.7 Wed 14:00 P1A

**Two dimensional planar SQUID-Gradiometer on a $SrTiO_3$-bicrystal** — •Uwe Schinkel[1], Christoph Becker[1], Alexander Steppke[2], Katharina Hoefer[1], Martin Pollithy[1], Veit Grosse[1], Sebastian Engmann[1], Frank Schmidl[1], and Paul Seidel[1] — [1]Friedrich-Schiller-Universität Jena, Institut für Festkörperphysik, Helmholtzweg 5, D-07743 Jena, Germany — [2]Max-Planck-Institut für Chemische Physik fester Stoffe, Nöthnitzer Str. 40, D-01187 Dresden, Germany

We designed a dc-SQUID-Gradiometer layout based on $YBa_2Cu_3O_{7-x}$ thin films on $SrTiO_3$ bicrystals and crossed bicrystals to detect the first order field gradient. In a planar configuration four galvanically coupled antenna structures can be read out by four dc-SQUIDs. Measuring the voltage modulation in an excitation coil changed magnetic field abnormal behaviour occurs. A redistribution of the screening current in the antennas can produce this disturbance. We present the layout, the preparation and the characteristics of each dc-SQUID. Especially the abnormal behaviours of the voltage modulation are analyzed. Therefore the influences of a homogenous magnetic field perpendicular to the gradiometer are studied.

TT 32.8 Wed 14:00 P1A

**Investigation of superconducting thin film structures prepared by nanoscale wedge polishing** — •Martin Pollithy[1], Katharina Höfer[1], Uwe Schinkel[1], Peter Michalowski[1], Veit Grosse[1], Frank Schmidl[1], Paul Seidel[1], Dagmar Meier[2], and Tanya Shapoval[2] — [1]FSU Jena, Institute of Solid State Physics, Helmholtzweg 5, D-07743 Jena, Germany — [2]IFW Dresden, Institute for Metallic Materials, PO Box 270116, D-01171 Dresden, Germany

The performance of dc-SQUID gradiometers depends very strong on the spread of the critical parameters Ic, Rn and Ls. After the preparation of high temperature superconducting devices it could be useful to tune the superconducting properties by decrease of the film thickness. On the other hand it is often helpful for sensor applications to realise a superconducting thin film structure with a smooth surface to avoid resistive or superconducting shunts in insulating layers on the top of the superconductor. In these investigations we use a mechanical wedge polishing procedure [1] to thin the superconducting devices (microbridges, dc-SQUIDs or dc-SQUID gradiometers) before and/or after the first measurements of the electrical properties. AFM and SEM measurements were done to characterise the film morphology. Temperature dependent measurements of the superconducting properties of microbridges, dc-SQUIDs and dc-SQUID gradiometer structures were realised. We discuss the possibilities and limitations of this procedure.

[1] T.Shapoval, S.Engel, M.Gründlich, D.Meier, E.Backen, V.Neu, B.Holzapfel, L.Schultz, Supercond. Sci. Tech. 21 (2008) 105015

TT 32.9 Wed 14:00 P1A

**Superconducting properties of YBCO thin film structures with gold nanoclusters** — •Marc Teichmann, Martin Pollithy, Katharina Höfer, Sebastian Engmann, Uwe Schinkel, Robert Hähle, Veit Grosse, Christoph Becker, Frank Schmidl, and Paul Seidel — FSU Jena, Institute of Solid State Physics, Helmholtzweg 5, D-07743 Jena, Germany

For our experiments we used laser ablation to prepare $YBa_2Cu_3O_{7-X}$ thin films with a film thickness of about 150 nm on (100) $SrTiO_3$ single crystalline substrates as well as on $SrTiO_3$ bicrystalls (24° and 30° grain boundary angle). X-ray, AFM and SEM investigations were done to determine the crystalline structure and morphology of the prepared thin films with and without gold nanoclusters. Ion beam etching with sample cooling was used to pattern microbridges as well as dc-SQUID and dc-SQUID gradiometer structures. The temperature dependence of the device and the contact resistance, the current-voltage characteristics at different temperatures and the magnetic field dependence were measured.

TT 32.10 Wed 14:00 P1A

**Transport measurements on melt-textured SEG-123 superconductors exhibiting nanostripes** — •Michael R. Koblischka[1], Marc Winter[1], Anming Hu[2], and Uwe Hartmann[1] — [1]Experimental Physics, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany — [2]Department of Physics, University of Waterloo, 200 Univ. Ave. West, Waterloo, ON, N2L 3P7, Canada

Transport measurements were performed on melt-textured, ternary light rare earth (LRE)-compounds $(Sm_{0.33}Eu_{0.33}Gd_{0.33})Ba_2Cu_3O_x$ (SEG) exhibiting self-organized nanostripes. The periodicity of these nanostripes ranges between 40 and 60 nm and extends over several tens of micrometers up to millimeters, as revealed by atomic force microscopy at ambient conditions [1]. Electrical contacts were prepared on the polished sample surface by means of electron-beam lithography, enabling the measurement of transport currents oriented parallel and perpendicular to the nanostripe direction. On decreasing the temperature from Tc, the data of the parallel direction deviate in intermediate fields (around 1 T) from the data of the perpendicular direction. At 85 K, there is a clear difference in jc between the two directions, with $j_c^{\mathrm{parallel}} > j_c^{\mathrm{perp}}$. Plotting the data in a scaling fashion shows that the peak positions are clearly different with $h_0^{\mathrm{parallel}} > h_0^{\mathrm{perp}}$, which indicates an increase of the $\delta T_c$ pinning.

[1] M.R.Koblischka et al., Jpn. J. Appl. Phys. 45, 2259 (2006).

TT 32.11 Wed 14:00 P1A

**Surface deformation caused by the Abrikosov vortex lattice** — Pavel Lipavsky[1,2], •Klaus Morawetz[3,4], Jan Kolacek[2], and Ernst Helmut Brandt[5] — [1]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 12116 Prague 2, Czech Republic — [2]Institute of Physics, Academy of Sciences, Cukrovarnická 10, 16253 Prague 6, Czech Republic — [3]Forschungszentrum Dresden-Rossendorf, PF 51 01 19, 01314 Dresden, Germany — [4]International Center for Condensed Matter Physics, 70904-910, Brasília-DF, Brazil — [5]Max Planck Institute for Metals Research, D-70506 Stuttgart, Germany

In superconductors penetrated by Abrikosov vortices, the magnetic pressure and the inhomogeneous condensate density induce a deformation of the ionic lattice. We calculate how this deformation corrugates the surface of a semi-infinite sample [1]. The effect of the surface dipole is included.

[1] Phys. Rev. B 77 (2008) 184509

TT 32.12 Wed 14:00 P1A

**Surface superconductivity and capacitance of superconductors under electric and magnetic fields** — •Klaus Morawetz[1,2], Pavel Lipavsky[3,4], Jan Kolacek[4], Ernst Helmut Brandt[5], and Michael Schreiber[1] — [1]Forschungszentrum Dresden-Rossendorf, PF 51 01 19, 01314 Dresden, Germany — [2]International Center for Condensed Matter Physics, 70904-910, Brasília-DF, Brazil — [3]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 12116 Prague 2, Czech Republic — [4]Institute of Physics, Academy of Sciences, Cukrovarnická 10, 16253 Prague 6, Czech Republic — [5]Max Planck Institute for Metals Research, D-70506 Stuttgart, Germany

A superconducting layer exposed to a perpendicular electric and parallel magnetic field is considered within the Ginzburg-Landau (GL) approach. The GL equation is solved near the surface and the surface energy is calculated [1,2]. The nucleation critical field is shown to be changed in dependence on the magnetic and electric field. Special consideration is payed to the induced magnetic-field effect caused by diamagnetic surface currents. The latter effect constitutes the main contribution to the effective inverse capacitance which determines the effective penetration depth. The surface energy becomes strongly dependent on the width of the sample. An experimental realization is suggested for determining the change in the effective capacitance of the layer.

[1] Phys. Rev. B 78 (2008)054525
[2] arXiv 0804.0138

TT 32.13 Wed 14:00 P1A

**The lateral S-(S/F)-S Josephson junctions** — •Ondrej Vávra, Wolfgang Pfaff, and Christoph Strunk — Inst. for Exp. and Appl. Physics, Univ. Regensburg, Germany

Up to now the proximity effect at the superconductor-ferromagnet (S-F) interface was mainly demonstrated by the transport properties across the S-F interface [A.A. Golubov, M.Yu. Kupriyanov, and E. Ilichev, Rev. Mod. Phys. **76**, 411 (2004).]. We present the results on lateral transport along the S-F interface and its utilization as a Josephson junction. We have prepared Nb based Josephson junctions which consist of Nb micro bridges with a $Pd_{0.95}Fe_{0.05}$ or Fe strip deposited perpendicular to the bridge. The width of the ferromagnetic

strip was varied between 50 and 800 nm. The critical current ($I_C$) of the Nb-$Pd_{0.95}Fe_{0.05}$ and Nb-Fe bi-layer, respectively, is found to be significantly reduced by the proximity effect with the ferromagnet.

We have studied the temperature and magnetic field (B) dependencies of the critical current. In magnetic field an interference pattern $I_C(B)$ is observed. In perpendicular magnetic field the junction exhibits $I_C(B)$ dependence similar to a Fraunhofer pattern which proves the dc Josephson effect. We also investigate the dependence of $I_C(B)$ oscillations on the orientation of the magnetic field. The control of the Josephson junction parameters is provided by third electrode connected to the F strip.

TT 32.14 Wed 14:00 P1A

**Observation of absolute negative resistance in mesoscopic samples of a-NbGe** — •Florian Otto[1], Ante Bilušić[1,2], Dinko Babić[3], Christoph Sürgers[4], and Christoph Strunk[1] — [1]Inst. for Exp. and Appl. Physics, Univ. Regensburg, Germany — [2]Fac. of Nat. Sciences, Univ. of Split, Croatia — [3]Dept. Physics, Univ. Zagreb, Croatia — [4]Phys. Inst. and DFG CFN, Univ. Karlsruhe, Germany

Local and nonlocal measurements on mesoscopic samples of amorphous NbGe, a high-$\kappa$ type-II superconductor with very low pinning, reveal peculiar features in close vicinity of the transition temperature $T_c$: in absence of magnetic field, both local and nonlocal DC voltage current characteristics clearly display absolute negative resistance in a small interval around zero current and a small temperature range immediately below $T_c$ . At the same time, a negative voltage is also observed in both local and nonlocal measurements of $R(T)$. The temperatures at which this occurs are consistently found to be around 0.95-0.96 $T_c$, which is clearly below the narrow superconducting transition region. Upon application of small external magnetic fields on the order of $B = 50\,\mathrm{mT}$, the effect can be suppressed. The origin of these completely unexpected features is not clear.

TT 32.15 Wed 14:00 P1A

**Spin mixing at Superconductor Ferromagnet Interfaces probed by non-local transport** — •Florian Hübler[1,2], Detlef Beckmann[1], Jakob Brauer[1], and Hilbert von Löhneysen[2,3] — [1]Forschungszentrum Karlsruhe, Institut für Nanotechnologie, P.O.-Box 3640, D-76021 Karlsruhe — [2]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, P.O.-Box 3640, D-76021 Karlsruhe — [3]Physikalisches Institut, Universität Karlsruhe, D-76128 Karlsruhe, Germany

We present experimental results on non-local conductance in multiterminal hybrid structures, where two or more ferromagnetic (F) contacts are attached to a single superconductor (S). For contacts with an insulating (I) tunnel barrier, and at energies below the energy gap of the superconductor, the non-local conductance is determined by the competition of crossed Andreev reflection (CAR) and elastic cotunneling (EC). In FISIF structures, the contributions of CAR and EC are expected to depend on the orientation of the magnetisation of the F contacts. Recently, an asymmetric conductance signal as consequenc of a finite spin-mixing angle has been predicted [1]. We observe first signs for similar signals in our structures.

[1] Kalenkov and Zaikin, Phys. Rev. B 76, 224506 (2007)

TT 32.16 Wed 14:00 P1A

**Crossover from 2D-3D behaviour in superconducting Nb/CuNi bilayers in a magnetic field** — •Jan-Michael Kehrle[2], Vladimir Zdravkov[1,2], Günter Obermeier[2], Roman Morari[1], Eugen Antropov[1], Andrei Prepelitsa[1], Claus Müller[2], Achim Wixforth[2], Siegfried Horn[2], Reinhard Tidecks[2], and Anatolie Sidorenko[1,2,3] — [1]Institute of Electronic Engineering and Industrial Technologies ASM, Kishinev, MD2028, Moldova — [2]Institut für Physik, Universität Augsburg, D-86159 Augsburg, Germany — [3]Institute of Nanotechnology (INT), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany

A dimensional crossover in an external magnetic field, applied parallel to the layers, has been found for superconductor/ferromagnet (S/F) bilayers of Nb/CuNi. For decreasing temperature the square-root 2D-behaviour of the upper critical magnetic field, Bc2||(T) on the temperature, in the vicinity of the critical temperature Tc switches to the linear 3D-behaviour below the crossover temperature, Tcr. The 2D-3D crossover also occurs concerning the temperature dependence of superconducting fluctuations in the critical fluctuation regime. The fluctuation conductivity exhibits a 2D-behaviour in zero- and weak magnetic fields close to Tc, switching to a 3D-behaviour in strong magnetic fields at low temperatures. In a S/F bilayer the quasi-one dimensional Fulde-Ferrel-Larkin-Ovchinnikov (FFLO) like state is realized, so that the superconducting properties are governed by interference effects of the pairing wave functions, i.e. by the pairing function flux through the S/F interface.

TT 32.17 Wed 14:00 P1A

**Structure and local electronic properties of Ag and Co/Ag on Nb(110)** — •Tihomir Tomanic[1], Christoph Sürgers[1], and Hilbert v. Löhneysen[1,2] — [1]Physikalisches Institut, Universität Karlsruhe — [2]Institut für Festkörperphysik, Forschungszentrum Karlsruhe

The local variation of the superconductive order parameter in hybrid structures of a superconductor S with a normal metal N or ferromagnet F is a topic of current interest. We have started a study of Ag and Co islands on Nb via scanning tunneling microscopy (STM) and spectroscopy (STS) at low temperatures.

As a prerequisite, we report on the surface structure of clean Nb(110) single crystals obtained after $Ar^+$ sputtering and flash heating up to 2300 °C in ultra-high vacuum. The atomic structure as well as the local superconducting properties have been explored by STM and STS at $T = 2.5$ and $T = 4.2\,\mathrm{K}$. We have studied the topography of a thin Ag overlayer (nominal thickness 5nm) on Nb(110) and of Co islands on top of the Ag overlayer. First results of the local electronic density of states derived from the current-voltage characteristics will be reported.

TT 32.18 Wed 14:00 P1A

**Angle-dependent investigation of the upper critical field in NbN/Sm-Co bilayers** — •Jan Engelmann, Silvia Haindl, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany

The coexistence of superconductivity and magnetism leads to new interesting phenomena like domain-, domain-wall-superconductivity and stray field effects. To investigate thin film bilayers of hard-magnetic Sm-Co with very fine defined domain structure and superconducting NbN, we fabricated these bilayers using pulsed laser deposition. The Sm-Co thin film layer was prepared in UHV on a MgO(100)-substrate with a Cr-buffer, and subsequently the NbN was grown in a nitrogen-atmosphere. Epitaxy and texture were measured via x-ray diffraction, the magnetic properties were determined by VSM -measurements. The angle-dependent upper critical field, $\mu_0 H_{c2}$, of the bilayer was investigated in detail by a standard four probe technique using a PPMS.

TT 32.19 Wed 14:00 P1A

**Turning a nickelate Fermi surface into a cuprate-like one through heterostructuring** — •Philipp Hansmann[1,2], Xiaoping Yang[1], Alessandro Toschi[2], Giniyat Khaliullin[1], Ole Krogh Andersen[1], and Karsten Held[2] — [1]Max Planck Institute for Solid State Research, Stuttgart, Germany — [2]Institute of Solid State Physics, Vienna University of Technology, Austria

Using the local density approximation and its combination with dynamical mean field theory, we show that electronic correlations induce a single sheet cuprate-like Fermi surface for $LaNiO_3/LaAlO_3$ heterostructures, even though both $e_g$ orbitals contribute to it. This is possible because the correlations shift one of the two sheets above the Fermi level. As there are also strong antiferromagnetic fluctuations, the low-energy electronic and spin excitations resemble those of high-temperature cuprate superconductors.

[1] P.Hansmann, X. Yang, A. Toschi, G. Khaliullin, O.K. Andersen, K. Held, (arXiv:0710.2778) (2008)

TT 32.20 Wed 14:00 P1A

**Decreasing excitation gap in Andreev billiards by disorder scattering** — •Florian Libisch[1], Jürgen Möller[1], Stefan Rotter[1], Maxim Vavilov[2], and Joachim Burgdörfer[1] — [1]TU–Vienna, Austria — [2]University of Wisconsin, USA

We investigate the distribution of the lowest-lying energy states in a disordered Andreev billiard by solving the Bogoliubov-de Gennes equation numerically [1]. Contrary to conventional predictions we find a decrease rather than an increase of the excitation gap relative to its clean ballistic limit. We relate this finding to the eigenvalue spectrum of the Wigner-Smith time delay matrix between successive Andreev reflections. We show that the longest rather than the mean time delay determines the size of the excitation gap. With increasing disorder strength the values of the longest delay times increase, thereby, in turn, reducing the excitation gap.

[1] F. Libisch, J. Möller, S. Rotter, M. G. Vavilov, J. Burgdörfer, Europhys. Lett. 82, 47006 (2008).

TT 32.21 Wed 14:00 P1A

**Behavior of the vortex-creep activation energy in $YBa_2Cu_3O_{7-\delta}/PrBa_2Cu_3O_{7-\delta}$ superlattices** — •Ayman El Tahan[1], Lucica Miu[2], Gerhard Jakob[1], and Hermann Adrian[1] — [1]Institute of Physics, University of Mainz, 55099 Mainz, Germany — [2]National Institute of Materials Physics, 77125 Bucharest, Romania

$YBa_2Cu_3O_{7-\delta}/PrBa_2Cu_3O_{7-\delta}$ (YBCO/PBCO) superlattices with a different ratio of the superconducting and insulating layer thicknesses were prepared by high-pressure dc sputtering. The vortex-creep activation energy U was determined by analyzing the in-plane resistive transition of 200 $\mu$m- and 10 $\mu$m-wide bridges with the external magnetic field B oriented along the c axis. We found that U is proportional to the thickness of YBCO, and does not depend on the PBCO thickness, when the latter exceeds two unit cells. The U(B) dependence is well described by $U(B) \propto B^{(1/2)}$. The observed behavior can be explained in terms of 2D collective pinning. Financial support by the MWFZ Mainz, the Humboldt foundation, and the government of Egypt is gratefully acknowledged.

TT 32.22 Wed 14:00 P1A

**Pinning investigation in NbN thin films** — •Tetyana Shapoval, Silvia Haindl, Jan Engelmann, Volker Neu, Bernhard Holzapfel, and Ludwig Schultz — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany

NbN thin films with $T_c$=16 K and a thickness of 100 nm were fabricated on MgO(100) substrates by UHV pulsed laser deposition by using a Nb (99.95%) target in nitrogen gas atmosphere. Low temperature magnetic force microscopic (LT-MFM) images were performed after field cooling in a magnetic field of -2 mT to study the temperature dependence of vortex distribution. At low temperatures vortices are organized in a slightly disordered Abrikosov lattice with an average inter-vortex distance of 930 nm. Increasing the temperature to above $T = 75\%T_c$ leads to a movement of vortices during the MFM scan, which is interpreted as a thermally activated depinning process initiated by the stray field of the tip. The local pinning force has been estimated from MFM-images and compared with global VSM magnetization measurements. In addition, the temperature dependence of the penetration depth, $\lambda$, was extracted from the magnetic field profiles of single vortices.

The work is partially funded from the European Community under the Sixth Framework Programme Contract Number 516858: HIPERCHEM, and SFB 463/A4.

TT 32.23 Wed 14:00 P1A

**Thermalization of energy in superconducting absorbers far from equilibrium: an experimental approach** — •Loredana Fleischmann, Richard Weldle, Philipp Ranitzsch, Jan-Patrick Porst, Andreas Fleischmann, and Christian Enss — Universität Heidelberg, Kirchhoff Institut für Physik, INF 227, 69120 Heidelberg

The use of superconducting energy absorbers for low temperature micro-calorimeters offers several advantages like the possibility to have high stopping power together with low heat capacity. Due to a still not well understood thermalization of the energy released by the interacting particle, the use of superconducting absorbers is present only in special cases. We investigated by means of magnetic calorimeters the time response of the detector signal upon the absorption of x-rays in a superconducting absorber. Metallic magnetic calorimeters are low temperature energy dispersive detectors composed by an energy absorber well thermally connected to a paramagnetic temperature sensor which resides in a small magnetic field. The change of magnetization following the absorption of energy is measured as a change of flux in a low noise high bandwidth dc-SQUID. In particular we investigated absorbers made of rhenium, aluminum and aluminum doped with 600ppm manganese. The experiments using the Al and Al:Mn were 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.

TT 32.24 Wed 14:00 P1A

**Low temperature metallic magnetic calorimeters for neutrino mass direct measurement** — •Jan-Patrick Porst, Falk von Seggern, Loredana Fleischmann, Andreas Fleischmann, and Christian Enss — Universität Heidelberg, Kirchhoff Institut für Physik, INF 227, 69120 Heidelberg

In the last years the mixing of the three neutrino flavor eigenstates through a unitary matrix has been experimentally proved. Presently one of the greatest challenges in neutrino physics is to establish the absolute value of the masses of the three neutrino mass eigenstates. The kinematic determination of electron neutrino and antineutrino mass by means of the analysis of calorimetric spectra of isotopes which undergo a beta or electron-capture decay, with especially low energy available for the decay itself, represents an interesting method. In fact this method is less affected by theoretical models defining branching ratio among different decay modes. For the beta decay the isotope with the lowest Q-value present in nature is the 187-Re (Q about 2.5 keV) while for the electron capture decay the best candidate known is the 163-Ho (Q about 2.5 keV). Since those experiments need to be extremely precise, they might suffer from unexpected systematic errors. It is therefore important to investigate in detail the performance of the detectors and the calorimetric spectrum. We present our results obtained with low temperature magnetic calorimeters designed for measuring low energy beta and electron capture spectra. We also discuss problematic and the possibly present systematic uncertainties using this kind of detectors.

TT 32.25 Wed 14:00 P1A

**Position Resolved High Resolution Particle Detection Using Magnetic Calorimeters** — •Christian Pies, Christian Domesle, Sebastian Kempf, Andreas Fleischmann, Loredana Fleischmann, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg, INF 227, 69120 Heidelberg

Low temperature micro-calorimeters are attractive x-ray and particle detectors for a large variety experiments due to their high resolving power and their energy dispersive character. With single pixel metallic magnetic calorimeters (MMC) an energy resolution of 2.7 eV for 6 keV x-rays was recently achieved. Quite some applications of MMCs would benefit greatly from the development of detector arrays, as they are position sensitive and allow for imaging, larger detection areas as well as the suppression of doppler-broadening in atomic spectroscopy at ion storage rings.

We recently developed two types of position sensitive MMC arrays. The first consists of 8 x-ray sensors, optimized for the energy range up to 100 keV, which are pairwise read-out by 4 dc-SQUIDs. The second prototype consists of a line of 8 large area absorbers for accelerated molecules, which are read-out by two dc-SQUIDs. To allow for this, two sets of paramagnetic sensors and pick-up coils are connected to the absorbers, one with increasing, one with decreasing sensitivity along the line of absorbers. In this case, the sum of the two signal channels represents the deposited energy and the normalized difference the position. We present data for both detectors and discuss general design considerations as well as the achievable energy resolution.

TT 32.26 Wed 14:00 P1A

**Towards MMC detector arrays: A microwave SQUID multiplexer** — •Sebastian Kempf, Andreas Fleischmann, Loredana Fleischmann, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg, Germany.

Metallic magnetic calorimeters (MMCs) have shown to be suitable detectors for x-ray photons or massive particles in areas like astronomy, nuclear as well as atomic physics. They provide high energy resolution, high quantum efficiency, large energy bandwidth and linearity. However for many applications large detection areas, high count rates or imaging capabilities are crucial. These requirements can be satisfied by combining single detectors into large detector arrays. Due to constraints on cryogenic wiring, heat load and complexity, it is hardly possible to route thousands of wires from room temperature to the detector array. Thus a technique able to read out a large number of channels with a small number of wires has to be set up.

Recently a microwave SQUID multiplexer for the readout of low-temperature detector arrays was proposed. In such a setup every pixel consists of a superconducting $\lambda/4$-resonator inductively coupled to an unshunted rf-SQUID that is again inductively coupled to an input coil. A current through this coil is transduced to a change of magnetic flux in the SQUID and thus shifts the circuit's resonance frequency. By capacitively coupling many of those circuits to a common transmission line, injecting a frequency comb and monitoring the phase of each resonator, it is possible to infer the initial detector signal. We discuss an adaption of such a setup for the readout of MMC detector arrays.

TT 32.27 Wed 14:00 P1A

**Coupling between coplanar waveguide resonators for multi-pixel kinetic inductance detectors** — •Gerd Hammer, Martin Herold, Stefan Wünsch, and Michael Siegel — Institut für Mikro- und Nanoelektronische Systeme, Universität Karlsruhe (TH), Karlsruhe, Deutschland

Coplanar resonators as core element of kinetic inductance detectors are suitable for large arrays in multi-pixel applications [1]. The readout of large arrays can be performed by simultaneous measurement of multiple channels using frequency domain multiplexing (FDM) [2]. We have studied the coupling of closely placed resonators for a multi-pixel design with a high packaging density. Superconducting resonators with niobium thin films on silicon substrates with different coupling to a transmission line have been designed, simulated and measured at liquid helium temperature. Results of the influence of coupling properties of closely placed resonators are presented and discussed in respect of a high packaging density.

[1] P. K. Day et al., Nature 425, 817 (2003).

[2] B. A. Mazin et al., Nucl. Instrum. Methods Phys. Res. A 558, 799 (2006).

TT 32.28 Wed 14:00 P1A

**Investigation of energy relaxation processes in NbN thin film using optical and IR irradiation** — •Dagmar Rall[1], Matthias Hofherr[2], Konstantin Ilin[2], Michael Siegel[2], Uli Lemmer[1], Alexei Semenov[3], and Heinz-Wilhelm Hübers[3] — [1]LTI, University of Karlsruhe, Germany — [2]IMS, University of Karlsruhe, Germany — [3]DLR Institute of Planetary Research, Berlin, Germany

Superconducting radiation detectors made from ultra-thin Niobium Nitride (NbN) films show high sensitivity (down to single-photon) and short response times (some ten ps), making them suitable for applications like astrophysics, spectroscopy and telecommunications. The electron energy relaxation processes and responsivity of thin NbN films and their dependence on the stoichiometry of NbN films and the critical dimensions of a device are investigated for further improvement and optimisation of the detection efficiency and speed. We present results on the study of the response of NbN thin film samples to optical and infra-red radiation. The NbN thin films with thickness from 3nm to 15nm were deposited by DC reactive magnetron sputtering onto heated sapphire substrates and patterned into lines with critical dimensions from less than 100nm up to several micrometers. The samples were kept at helium temperatures, electrically biased and excited by fs laser pulses or amplitude modulated (up to 15GHz) laser radiation. The absorbed energy is redistributed by inelastic scattering processes among electron and phonon subsystems of the NbN film. These interaction processes result in a change of resistivity of the film, which is measured as a change of voltage across the sample.

TT 32.29 Wed 14:00 P1A

**Superconducting NbN detectors for synchrotron radiation** — Alexei Semenov[1], Konstantin Il'in[2], Michael Siegel[2], •Heiko Richter[1], and Heinz-Wilhelm Hübers[1] — [1]DLR Instiute of Planetary Research, 12489 Berlin — [2]Instututе of Micro- and Nanoelectronic Systems, University of Karlsruhe

We present development of a special type of hot-electron bolometers that is designed to optimally detect pulsed synchrotron radiation in the terahertz frequency range. The enlarged log-spiral antenna makes it possible to sense the low-frequency part of the spectrum in coherent and non-coherent regime. The device follows the layout of a typical HEB mixer. The radiation is coupled quasioptically with the 6-mm elliptical silicon lens. The bolometer has the noise equivalent power 2 nW per square root Hz and responds to a few picoseconds long radiation pulse with the electric pulse having full width at half maximum of 160 ps. We present results obtained with this type of detector at different synchrotron facilities and discuss possible improvements of the detector performance.

TT 32.30 Wed 14:00 P1A

**Three dimensional near-field radiation imaging up to the THz-regime** — •Christian Brendel, Felix Stewing, and Meinhard Schilling — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Hans-Sommer-Strasse 66, D-38106 Braunschweig, Germany

Microwave devices are operated at very high frequencies ranging up to the THz-regime. For characterization of transmission lines, filters and directional couplers at these very high frequencies new instruments are required. We present the set-up and applications of our scanning THz-electronics prober STEP. As scanning sensor we employ a Josephson junction from the high-temperature superconductor YBa2Cu3O7 on a vibrating cantilever prepared from a LaAlO3-bicrystal. This superconducting detector is cooled to a temperature of about 30 K by a cryocooler. Despite this low temperature of the cantilever, which is about 10 um above its surface, the microwave device under investigation remains at room temperature. Based on this set up in a vacuum chamber we investigate the microwave properties of devices at frequencies of up to 762 GHz with a spatial resolution of 10 um far below the corresponding wavelengths. For the higher frequencies we couple far-infrared laser radiation from a CO2-laser pumped molecular laser system into the chamber. Applications of this novel instrument to microwave devices are demonstrated.

TT 32.31 Wed 14:00 P1A

**THz-range free-electron laser ESR spectroscopy: techniques and applications in high magnetic fields** — •Mykhaylo Ozerov, E. Čižmár, D. Kamenskyi, S. Zherlitsyn, T. Herrmannsdörfer, J. Wosnitza, and S.A. Zvyagin — Hochfeld-Magnetlabor Dresden (HLD), Forschungszentrum Dresden - Rossendorf (FZD), Dresden, Germany

The successful use of picosecond-pulse free-electron-laser (FEL) radiation for the continuous-wave THz-range electron spin resonance (ESR) spectroscopy has been demonstrated. The unique combination of two linac-based FELs (covering the wavelength range of 4 - 250 $\mu$m) with high magnetic fields at the Research Center Dresden-Rossendorf (FZD) allows for tunable-frequency ESR spectroscopy in an extraordinary broad frequency range of 1.2 - 75 THz in magnetic fields up to $\sim$ 70 T. The new approach is of particular importance for studying magnetic excitations in materials exhibiting field-induced phenomena (including magnetic phase transitions) and in spin systems with a large zero-field splitting. The performance of the spectrometer is illustrated with ESR spectra obtained in the low-dimensional organic material $(C_6H_9N_2)CuCl_3$ and the multiferroic compound $YMnO_3$

This work was made in collaboration with R. Wünsch, W. Seidel, H.D. Zhou, C. Wiebe.

TT 32.32 Wed 14:00 P1A

**Verfahren zur Messung anisotroper thermischer Ausdehnungskoeffizienten an großen Proben** — •Matthias Schneider, Armin Binneberg, Bernhardine Schumann, Björn Grossmann und Jürgen Klier — Institut für Luft- und Kältetechnik gemeinnützige Gesellschaft mbH, Bertolt-Brecht-Allee 20, D-01309 Dresden

Es wurde ein neuartiges optisches Verfahren zur Messung des makroskopischen thermischen Ausdehnungskoeffizienten entwickelt, bei welchem dessen Verhalten in unterschiedlichen Richtungen gleichzeitig ermittelt werden kann. Zudem zeichnet es sich durch die Möglichkeit aus, Proben mit Abmessungen bis zu einigen Dezimetern zu vermessen. Hauptsächliches Anwendungsgebiet ist die Untersuchung neuer Verbundwerkstoffe für thermische Isolierungen mit meist stark anisotropem Ausdehnungsverhalten. Das Messprinzip kann für unterschiedliche kryogene Medien eingesetzt werden. Darüber hinaus wird mit einem Messgerät für die Wärmeleitfähigkeit, das auf der Ermittlung der Abdampfrate einer kryogenen Flüssigkeit basiert, ein weiteres Prinzip zu Messung einer thermodynamischen Größe an ausgedehnten Proben vorgestellt.

TT 32.33 Wed 14:00 P1A

**A scanning tunneling microscope for low temperatures** — •Michael Marz[1,2], Gernot Goll[1], and Hilbert v. Löhneysen[1,2,3] — [1]Physikalisches Institut, Universität Karlsruhe, 76128 Karlsruhe — [2]DFG-Centrum für Funktionelle Nanostrukturen der Universität Karlsruhe (TH), 76128 Karlsruhe — [3]Institut für Festkörperphysik Forschungszentrum Karlsruhe, 76021 Karlsruhe

Scanning tunneling microscopy (STM) and spectroscopy (STS) are widely used to study topological and electronic properties of conducting materials. We installed a home-built STM into a dilution refrigerator, where we can reach temperatures down to 30 mK and apply magnetic fields up to 13 T. Calibration of the piezo of the scanning head was done on HOPG and $NbSe_2$ at room temperature, on both we achieved atomic resolution. At low temperatures we imaged with atomic resolution the topography of $NbSe_2$ as well as the flux-line lattice in small magnetic fields. The lattice constant $a$ of the Abrikosov lattice shows the expected field dependence $a \propto 1/\sqrt{B}$. Spectroscopy clearly shows the superconducting density of states and Andreev bound states in the vortex core. The energy gap determined from a fit of the $dI/dV$ vs. $V$ curves reveals a distribution of the gap values probably

due to the presence of the charge-density wave in $NbSe_2$.

TT 32.34 Wed 14:00 P1A

**Design of a 300 mK, UHV, 9 T scanning tunneling microscope** — •Danny Baumann[1], Torben Hänke[1], Paul Sass[1], Christian Hess[1], Marko Kaiser[2], Ralf Voigtländer[2], Dirk Lindackers[2], and Bernd Büchner[1] — [1]IFW Dresden, Institute for Solid State Research, P.O. Box 270116, D-01171 Dresden, Germany — [2]IFW Dresden, Bereich Forschungstechnik, P.O. Box 270116, D-01171 Dresden, Germany

We present our progress in assembling an ultra high vacuum (UHV) scanning tunneling microscope (STM). This STM is designed for operating temperatures down to 300 mK and magnetic fields up to 9 T. Our system comprises an in-situ tip exchange and coarse xy-sample positioning system. Furthermore, five electrical leads are available on the sample holder to combine STM with transport measurements. The STM is mounted on a $^3$He UHV cryostat which is connected to a three-chamber UHV system. In this work we will present first measurements on standard samples at low temperatures and UHV conditions.

TT 32.35 Wed 14:00 P1A

**Design of a dip stick 4K scanning tunneling microscope** — •Ronny Schlegel[1], Torben Hänke[1], Danny Baumann[1], Christian Hess[1], Marko Kaiser[2], Ralf Voigtländer[2], Dirk Lindackers[2], and Bernd Büchner[1] — [1]Institut für Festkörperorperforschung,IFW Dresden — [2]Bereich Forschungstechnik, IFW Dresden

We present the design of a Scanning Tunneling Microscope (STM) for measurements at variable temperatures from 300K down to 4K. The microscope will be placed in a $^4$He cryogenic system with a superconducting coil. This will allow measurements in cryogenic vacuum and optionally in static magnetic fields up to 17 Tesla. The STM is equipped with a sample cleaving mechanism to prepare samples in vacuum and at low temperatures.

TT 32.36 Wed 14:00 P1A

**Control of vibrational modes and dissipation in nanomechanical resonators** — •Stefan Bächle, Clemens Müthing, Elke Scheer, and Artur Erbe — Department of Physics, University of Konstanz

Nanomechanical systems are of interest for a wide range of practical applications (e.g. sensors, actuators) as well as for basic research. The main topic of the latter is to get a better understanding of the processes taking place at the transition of the macro-mechanical and quantum-mechanical regime. Scaling down a resonator to a point when its eigenfrequency exceeds 1 GHz, $\hbar\omega$ can be larger than the thermal energy $k_BT$. To reach this limit resonators with very low dissipation and damping are required. Up to date the correlation between e.g. size and shape of a nanomechanical resonator is still not understood. We present a magneto-electrical and an optical measurement setup, the sample preparation, as well as Finite Element Simulations on nanomechanical resonators. The eigenfrequencies of these silicon cantilever resonators are between several hundred MHz and up to 5GHz. The measurement setup is based on a HF-signal applied to the resonator, which is placed in a cryostat at 4K. A magnetic field of 1T up to 10T is applied perpendicularly to the samples surface. As a result the resonator is excited and starts to oscillate due to the Lorentz force. The optical measurements are based on a method called ASOPS (Asynchronous Optical Sampling).