TT 33 Superconductivity: Vortex Dynamics, Vortex Phases, Pinning

Time: Friday 10:15–12:30 Room: HSZ 304

TT 33.1 Fri 10:15 HSZ 304

Fluxoid quantization effect on the specific heat of mesoscopic superconductors — •Florian Ong[1], Olivier Bourgeois[1], Sergey Skipetrov[2], and Jacques Chaussy[1] — [1]CRTBT-CNRS 25 Avenue des Martyrs BP 166 38042 GRENOBLE cédex 9 France — [2]LP2MC-CNRS *(same address)*

Up to now, despite their deep fundamental relevance, thermal properties of matter stuctured at the nanoscale have not received much attention. Here we present highly sensitive specific heat measurements of mesoscopic superconductors, at low temperature (down to 0.5 K) and under a tunable magnetic field (up to 1 T).

Our calorimeter is a thin suspended silicon membrane, containing a heater and a thermometer, on which nanostructures are deposited after an e-beam lithography. Using a temperature oscillation method and ultra low noise electronics, the resolution $\frac{\Delta C}{C}$ can reach 5.10^{-5}.

We investigated thin Aluminium loops [1] and disks of 1 to 2.5 μm in diameter, a size closed to the superconducting coherence length $\xi(T)$ at 1 K. When sweeping the magnetic field H at a fixed temperature the behavior of the specific heat C is strongly governed by the fluxoid quantization. Indeed $C(H)$ exhibits a periodicity of $n \times \Phi_0$ (n is an integer depending on the temperature, and on the sample topology and size ; $\Phi_0 = h/2e$ is the superconducting flux quantum). These oscillations are the signatures of phase transitions between different vortex states, and can be described within the framework of the Ginzburg-Landau theory.

[1] O. Bourgeois, S. Skipetrov, F. Ong, J. Chaussy, Phys. Rev. Lett. 94, 0557007 (2005)

TT 33.2 Fri 10:30 HSZ 304

Temperature Dependent Matching in a Periodic Pinning Lattice with Disorder — •J. Eisenmenger[1], M. Oettinger[1], C. Steiner[1], C. Pfahler[1], A. Plettl[1], H.-G. Boyen[1], A. Ethirajan[1], P. Walther[2], and P. Ziemann[1] — [1]Abteilung Festkörperphysik, Universität Ulm, D-89069 Ulm, Germany — [2]Zentrale Einheit Elektronenmikroskopie, Universität Ulm, D-89069 Ulm, Germany

We prepared a lattice of nanoscaled artificial pinning centers (APCs) into a Nb film. The patterning technique is based on self-organization of inverse micelles of diblock-copolymers on a substrate. The resulting lattice of APCs mirrors the order of the micellar array which is triangular on the short range, but loses its directional order for larger distances. A unique feature of such prepared samples is that, in contrast to perfectly ordered pinning arrays, the matching field, as defined by the field where the critical current I_c has a maximum, depends on temperature. At the first glance any temperature dependence is unexpected, since the value of matching field for a triangular lattice $B_1 = (2\Phi_0)/(\sqrt{(3)}a^2)$ only depends on the lattice constant a of the APCs and the flux quantum Φ_0, which both are temperature independent. Several possible interpretation of this unusual behavior are discussed. In particular it is considered that a is not a fixed value for the entire self-assembled APC lattice but varies over a certain range.

TT 33.3 Fri 10:45 HSZ 304

Nonlocal Vortex Dynamics in Narrow Superconducting Channels — •Andreas Helzel[1], Ivan Kokanović[2], Dinko Babić[2], and Christoph Strunk[1] — [1]Institut für experimentelle und angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]Department of Physics, Faculty of Science, University of Zagreb, Bijenička 32, HR-10000 Zagreb, Croatia

We investigated superconducting microstructures composed of a vertical wire crossed by two horizontal wires. In presence of an external magnetic field, a supercurrent in the upper horizontal wire drives a flow of vortices in the vertical wire. This results in a nonlocal voltage response in the lower wire [1]. We use very low pinning amorphous NbGe as superconductor, resulting in a 100 times larger nonlocal response compared to [1] and a moderate decrease when varying the channel length between 2 and 5 μm. Comparing with the local flux flow properties, we observe that the nonlocal flux flow is maximal around the irreversibility line of plain NbGe wires and extends up to B_{c2}. In the regime of very few vortex rows in the channel reproducible fluctuations occur in the nonlocal signal, which can be understood as jamming effects near the detector cross.

[1] Grigorieva et. al., Phys. Rev. Lett. 92, 237001 (2004)

TT 33.4 Fri 11:00 HSZ 304

Bending of magnetic avalanches in MgB_2 thin films — •J. Albrecht[1,2], A. T. Matveev[1,2], M. Djupmyr[1], H.-U. Habermeier[2], and G. Schütz[1] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, 70569 Stuttgart

The penetration of magnetic flux lines into a superconductor above the lower critical field happens not necessarily in a regular way. It is found that under particular conditions a chaotic penetration in form of magnetic avalanches occurs. These avalanches are closely related to the so called thermomagnetic instability, which identifies local heating due to flux line movement as the origin of the effect. In case of MgB_2 thin films these avalanches are found only below $T = 10$ K and are suppressed by a covering metallic layer with high thermal conductivity and sufficient thickness. These avalanches are observed in case of partly gold covered MgB_2 films by the magnetooptical Faraday-effect. The investigation of avalanches propagating into a gold covered region revealed a change of the propagation direction depending on the incident angle of these avalanches.

TT 33.5 Fri 11:15 HSZ 304

Overcritical currents across grain boundaries in YBaCuO thin films — •Christian Jooss[1], Eva Brinkmeier[1], and Harald Heese[2] — [1]Institut für Materialphysik, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Institut für Numerische Mathematik, University of Göttingen, Germany

The current distribution in thin superconducting films can be strongly modified by the presence of soft magnetic environments. A soft magnet put parallel to a thin film edge can reduce or completely prevent flux entry and therefore stabilize Meissner screening currents in the film. This effect is of particular importance for the modification of the current distributions across grain boundaries in high-Tc superconductors, where the intergranular critical current density strongly depends on the flux which penetrates into the grain boundary. Furthermore, using special magnetic arrangements, asymmetric flux and current distributions can be obtained. An increase of the grain boundary critical current is obtained in the Meissner state, compared to the flux penetrated states [1]. The experimental studies via quantitative magneto-optical imaging are combined with theoretical calculations of the flux and current density distributions of superconducting strips in magnetic environments of arbitrary shape. The theoretical simulations are obtained by considering a boundary value problem for the Laplace equation as a mathematical model, which is then treated via integral equation methods.

[1] Ch. Jooss, E. Brinkmeier and H. Heese, Phys. Rev. B **72** (2005) 144516.

TT 33.6 Fri 11:30 HSZ 304

Anisotropic temperature-dependent current densities in vicinal YBCO — •Märit Djupmyr and Joachim Albrecht — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

Thin epitaxial films of $YBa_2Cu_3O_{7-\delta}$ grown on vicinal cut substrates exhibit a substantial anisotropy of the critical current density j_c in the film plane. By means of quantitative magneto-optical analysis it is possible to independently investigate the current densities along the two occurring current directions. A detailed analysis of the temperature dependence of the critical currents in the range of $T = 5 - 90$ K will be shown. Completely different behavior of $j_c(T)$ along the different directions were found. Describing the data by a step-wise power-law ansatz allows to distinguish between different current limiting mechanisms like thermal depinning and depairing which are important in different temperature ranges.

[1] S. Brück and J. Albrecht, Phys. Rev. B **71**, 174508 (2005)
[2] M. Djupmyr, G. Cristiani, H.-U. Habermeier and J. Albrecht, Phys. Rev. B, submitted

TT 33.7 Fri 11:45 HSZ 304

Defect Melting of Vortices in High-T_c Superconductors — •Jürgen Dietel and Hagen Kleinert — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

We set up a melting model for vortex lattices in high-temperature superconductors based on the continuum elasticity theory. The model

is Gaussian and includes defect fluctuations by means of a discrete-valued vortex gauge field. We derive the melting temperature of the lattice and predict the size of the Lindemann number. Our result agrees well with experiments for $YBa_2Cu_3O_{7-\delta}$, and with modifications also for $Bi_2Sr_2CaCu_2O_8$. We calculate the jumps in the entropy and the magnetic induction at the melting transition.

TT 33.8 Fri 12:00 HSZ 304

Microscopic Study of Pinning Mechanisms in YBCO HTSC Films — •Tetyana Shapoval, Volker Neu, Ulrike Wolff, Ruben Hühne, Jens Hänisch, Bernhard Holzapfel, and Ludwig Schultz — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany

The direct microscopic imaging of flux lines is a powerful tool for the understanding of vortex pinning mechanism at natural and artificial defects and can help to increase the critical current density. For these investigations a low-temperature scanning probe microscope (Omicron Cryogenic SFM) is used, which allows AFM, MFM and STM/STS measurements in UHV combined with magnetic fields of 7 T (vertical) and 3 T (transversal) at low temperatures (9 K - 300 K). Flux lines of an YBCO film have been successfully imaged by measuring their stray field in MFM modus. The 300 nm thick film with mean roughness less than 10 nm has been prepared by off-axis PLD and has been cooled down in the microscope to 7.7 K in a magnetic field of 3 mT prior to imaging. The number of vortices that we observed corresponds to the theoretically expected one. Whereas a constant current leads to the unacceptable heating of the sample, the use of current pulses allows transport measurements, avoiding thermal movement of vortices. The depinning mechanism is studied on a structured YBCO film by in situ imaging of flux lines under the influence of increasingly larger current pulses.

TT 33.9 Fri 12:15 HSZ 304

How the Flux Line Lattice in the Anisotropic High-T_c Superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ Melts: A Magnetic Force Microscopy study — •Alexander Schwarz[1], Marcus Liebmann[2], Ung Hwan Pi[1], and Roland Wiesendanger[1] — [1]University of Hamburg, IAP, Jungiusstr. 11, 20355 Hamburg — [2]Present Address: RWTH Aachen, Department of Physics, 52056 Aachen

The behavior of a trigonal flux line lattice corresponding to a flux density of about 3.5 mT was investigated in a $Bi_2Sr_2CaCu_2O_{8+\delta}$ single crystal upon increasing the temperature stepwise from 5.1 K towards T_c. In this highly anisotropic material flux lines consist of relative weakly bound pancake vortices confined to the copper oxide planes. Magnetic force microscopy images recorded with single flux line resolution revealed a temperature dependence of the regularity of the long-range order and the apparent flux-line size. Both observations can be explained by the interplay between the temperature dependence of the London penetration depth, collective pinning and subsequent depinning above 30 K, thermal motion of the vortices and lateral dragging by the force sensor itself. At the highest temperature the typical flux line contrast composed of a coherent alignment of pancake vortices along the crystal c-axis disappeared. Instead, a liquid-like behavior of individual pancakes can be observed.