TT 58: SC: Vortex Dynamics, Vortex Phases, Pinning

Time: Thursday 17:30–19:00 Location: HSZ 301

TT 58.1 Thu 17:30 HSZ 301

Study of the imperfect Meissner effect in niobium — •Sarah Aull, Oliver Kugeler, and Jens Knobloch — Helmholtz-Zentrum Berlin

When cooling niobium below the critical temperature T_c in the presence of a magnetic below H_{c1}, the magnetic field is expected to be expelled from the sample via the Meissner effect.

However, even below H_{c1} one observes flux trapping - presumably at pinning centers such as impurities and lattice defects - leading to an incomplete Meissner effect or even suppression of the Meissner effect entirely.

We measured the level of flux trapping in niobium samples that have undergone several different treatments commonly employed for the production of superconducting RF cavities, such as chemical and heat treatment. The dependance on the material crystallinity and the influence of spatial and temperoral temperature gradients during cooldown were investigated as well.

TT 58.2 Thu 17:45 HSZ 301

The $I_c(H)$-$T_c(H)$ phase boundary of superconducting Nb thin films with periodic and quasiperiodic antidot arrays — •D. Bothner[1], M. Kemmler[1], R. Cozma[1], V. Misko[2], F. Peeters[2], F. Nori[3], R. Kleiner[1], and D. Koelle[1] — [1]Physikalisches Institut and Center for Collective Quantum Phenomena, Universität Tübingen, Germany — [2]Departement Fysica, Universiteit Antwerpen, Belgium — [3]Advanced Science Institute, RIKEN, Japan

The magnetic field dependent critical current $I_c(H)$ of superconducting thin films with artificial defects strongly depends on the symmetry of the defect arrangement. Likewise the critical temperature $T_c(H)$ of superconducting wire networks is heavily influenced by the symmetry of the system. Here we present experimental data on the $I_c(H)$-$T_c(H)$ phase boundary of Nb thin films with artificial defect lattices of different symmetries. For this purpose we fabricated 60 nm thick Nb films with antidots in periodic (triangular) and five different quasiperiodic arrangements. The parameters of the antidot arrays were varied to investigate the influence of antidot diameter and array density. Experiments were performed with high temperature stability ($\Delta T < 1\,\mathrm{mK}$) at $0.5 \leq T/T_c \leq 1$. From the I-V-characteristics at variable H and T we extract $I_c(H)$ and $T_c(H)$ for different voltage and resistance criteria. The experimental data for the critical current density are compared with results from numerical molecular dynamics simulations. We focus on novel quasicrystalline ordering phenomena and the efficient suppression of vortex mobility as reported in V. Misko *et al.*, Phys. Rev. B **82**, 184512 (2010).

TT 58.3 Thu 18:00 HSZ 301

Vortex attraction and vortex clusters — •Ernst Helmut Brandt — Max-Planck-Institut für Metallforschung, Stuttgart

While the Abrikosov vortices in superconductors usually repel each other, there are cases when the vortex interaction has an attractive tail and thus a minimum. This may lead to vortex clusters and chains. Decoration pictures then may look like in the intermediate state of type-I superconductors, showing lamellae or islands of Meissner state or surrounded by Meissner state, but now the normal regions are filled with Abrikosov vortices that are typical for type-II superconductors in the mixed state. Such intermediate-mixed state was observed and investigated in detail in pure Nb, TaN and other materials 40 years ago [1-3]. Recently it was possibly also observed in MgB_2 [4] where it was simply ascribed to the existence of two superconducting electron bands, one of type-I and one of type-II. We expect [5] that the complicated two-band electronic structure of MgB_2 possessing a single transition temperature may indeed lead to vortex interaction with an attractive tail if evaluated numerically.

[1] U. Essmann and H. Träuble, Sci. Am. **224**, 75 (1971).
[2] J. Auer and H. Ullmaier, Phys. Rev. B **7**, 136 (1973).
[3] E. H. Brandt and U. Essmann, phys. stat. sol.(b) **144**, 13-38 (1987).
[4] V. Moshchalkov et al., Phys. Rev. Lett. **102**, 117001 (2009).
[5] E. H. Brandt and M. P. Das, Journal of Superconductivity and Novel Magnetism, in print.

TT 58.4 Thu 18:15 HSZ 301

Quantitative interpretation of the flux lines arrangement and their physical properties in superconducting materials. — •Henry Stopfel[1], Tetyana Shapoval[1], Dmytro S. Inosov[2], Volker Neu[1], Ulrike Wolff[1], Silvia Haindl[1], Jan Engelmann[1], Bernhard Holzapfel[1], Ji Tae Park[2], Dunlu L. Sun[2], Chengtian T. Lin[2], and Ludwig Schultz[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, 01171 Dresden, Germany — [2]Max Planck Institute for Solid State Research, Heisenbergstraße 1, 70569 Stuttgart, Germany

In superconducting thin films as well as in non-ideal single crystals the distribution of magnetic flux quanta is affected by existing defects. This interplay between repulsive vortex-vortex interaction and attractive pinning ends up in a strongly disordered vortex arrangement. Visualization of flux lines with magnetic force microscopy (MFM) followed by the quantitative analysis of data offers direct insight into pinning mechanism on a local scale. We have performed quantitative analysis of MFM images of two superconductors: single crystalline $BaFe_{2-x}Co_xAs_2$ and NbN thin films. Statistical evaluation of the images allows us to conclude about the existence of a short range hexagonal order in the FeAs crystal with strong pinning sites[1]. Evaluation of the measured signal in NbN thin films gives us an information about the local pinning force as well as the magnetic penetration depth.

[1] Inosov et al. PRB 81 014513 (2010)

TT 58.5 Thu 18:30 HSZ 301

Formation and propagation of flux avalanches in MgB_2 films — •Sebastian Treiber[1], Claudia Stahl[1], and Joachim Albrecht[2] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstrasse 3, 70569 Stuttgart, Germany — [2]Hochschule Aalen, Beethovenstrasse 1, 73430 Aalen, Germany

Devices made of MgB_2 are substantially limited by the presence of magnetic flux avalanches at temperatures below 10 K. In this case, quickly moving magnetic vortices create large amounts of heat and magnetic noise.

We found out, that it is necessary to distinguish between mechanisms which are responsible for the formation and the propagation of these avalanches [1]. In addition to the existing knowledge, described in Ref. [2], avalanches form preferably in granular areas with lower current density. This makes a nonlocal description for avalancheformation necessary. Mechanisms for avalanche-propagation are still under discussion. Since propagation depends on many factors, one has to consider thermal, electrical and superconducting properties as well as the microstructure of the sample. The diverse consequences on formation and propagation explains the preference of avalanches for inhomogeneous superconductors.

[1] S. Treiber and J. Albrecht, New J. Phys. **12**, 093043 (2010)
[2] J. Albrecht *et al.*, Phys. Rev. Lett. **98**, 117001 (2007)

TT 58.6 Thu 18:45 HSZ 301

Influence of dissipation on flux patterns in type-II superconductors — •Constantin Tomaras and Stefan Kehrein — Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München, Theresienstr. 37, D- 80333 München, Germany

Topological quantum field theories constitute the present frontier of theoretical physics [1]. Quite the *oldest* example is the theory of superconductivity, where the appropriate topological charge is just the number of condensed gauge bosons. We formulate a non-equilibrium BCS theory ($d \geq 2$) in presence of a continuous measurement of the local order parameter $\Delta_{BCS} = \langle \Psi_\downarrow^\dagger \Psi_\uparrow^\dagger \rangle$. This allows for local annihilation of pairs of vortices with opposing winding number, while the global phase (∼number of particles-number of holes) is conserved. Depending on the initial flux pattern, the constraint yields to domain wall formation and eventually a percolation transition. Our theory is in agreement with the seminal paper of Toussiant and Wilczek [2], and relevant for recent Hall probe microscopy experiments [3].

[1] E. Witten, Comm. Math. Phys. 121, 3, 351-399 (1989).
[2] D. Toussaint, F. Wilczek, J. Chem. Phys. 78, 2642 (1983).
[3] A. Silhanek et al., Phys. Rev. Lett. 104, 017001 (2010).