TT 33: Superconductivity: Vortex Physics

Time: Tuesday 9:45–11:00 Location: HSZ 201

TT 33.1 Tue 9:45 HSZ 201

Dynamics of superconductor vortices in finite-thickness Nb open microtubes — •Vladimir M. Fomin[1], Renat R. Dusaev[2], Roman O. Rezaev[2,3], and Oliver G. Schmidt[1,4] — [1]Institute for Integrative Nanosciences, IFW-Dresden, D-01069 Dresden, Germany — [2]Tomsk Polytechnic University, Tomsk, 634050, Russia — [3]Moscow Engineering Physics Institute, Moscow, 115409, Russia — [4]Material Systems for Nanoelectronics, Chemnitz University of Technology, D-09107 Chemnitz, Germany

Combination of reduced dimensionality with curved geometry in rolled-up superconductor micro- and nanotubes is a rich source of novel vortex dynamics [1,2]. Numerical modeling of a realistic finite-thickness Nb open microtube in a magnetic field orthogonal to the tube axis has been performed within the Ginzburg-Landau approach. An increase of thickness enhances the vortex-vortex interaction which results in a steady configuration with a reduced number of vortices and extends the upper magnetic field, at which the vortex dynamics occur, by a factor of two at least. This leads to new vortex dynamics as compared to the zero-thickness model. In particular, a regime is revealed where a configuration of vortices is fixed in the region far from the tube ends, while in the vicinity of the ends vortices nucleate at the top and bottom sides and then move toward each other until they annihilate as a vortex-antivortex pair.

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[1] V. M. Fomin, R. O. Rezaev, O. G. Schmidt, Nano Lett. 12, 1282 (2012)
[2] R. O. Rezaev, V. M. Fomin, O. G. Schmidt, Physica C 497, 1 (2014)

TT 33.2 Tue 10:00 HSZ 201

Neutron scattering studies of domain structures in type-II superconductor Niobium — •Tommy Reimann[1,2], Michael Schulz[1,2], Sebastian Mühlbauer[1], Christian Grünzweig[3], and Peter Böni[2] — [1]Heinz Maier-Leibnitz Zentrum (MLZ), TU München, Garching (D) — [2]Physikdepartment E21, TU München, Garching (D) — [3]Paul-Scherrer-Institut, Villigen (CH)

In the intermediate mixed state (IMS) of a type II superconductor (SC), the sample splits up into Meissner domains and Shubnikov domains which carry the vortex lattice (VL). A detailed investigation of these domain patterns offers the possibility to study general characteristics of domain nucleation and morphology as well as the physical properties of vortex-vortex and vortex-pinning interactions. In this talk we show that ultra small angle neutron scattering (USANS) can be used for the identification of VL properties. We have studied the VL domain morphology in a Nb single crystal disc that exhibit strong vortex pinning. USANS is sensitive to structures with sizes up to 20 microns and is therefore capable to probe IMS domains which is not possible with the commonly used small angle neutron scattering (SANS). Futhermore, USANS averages over the whole sample and hence probes the bulk of the material in contrast to magneto optical methods. Our investigation on the IMS of Nb reveals a preferred domain size with a strong dependence on magnetic field and sample thickness. Surprisingly , the average domain size is nearly independent of the temperature in a field cooled measurement giving some hint on the nature of field expulsion in the IMS of samples with significant pinning.

TT 33.3 Tue 10:15 HSZ 201

Spatial-dependent critical magnetic field for the suppression of superconductivity in a single Pb island with non-uniform thickness — •Augusto Leon Vanegas[1], Agnieszka Stepniak[1], Michael Caminale[1], Hirofumi Oka[1], Dirk Sander[1], and Jürgen Kirschner[1,2] — [1]Max-Planck-Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg

We have studied the superconducting properties of Pb islands of $7-10$ layers thickness and sizes of 1600 – 10000 nm^2 on Pb/Ag/Si(111) with a ^{3}He cooled scanning tunnelling microscope (^{3}He-STM) with a vector magnetic field. Spatially resolved scanning tunnelling spectroscopy(STS) at 1.8 K shows a uniform superconducting gap across the islands at 0 T. We have measured the differential conductance at zero bias (ZBC) across several islands with varying the magnetic field perpendicular to the island surface. We identify the vortex formation field (H_{C1}) for islands larger than 5000 nm^2 and the critical field for suppressing superconductivity (H_{C2}) in the islands. Below H_{C1} the islands remain superconducting with small spatial variations of the ZBC from the centre to the edge of the island, which we ascribe to Meissner screening currents along the island perimeter. Between H_{C1} and H_{C2} spectroscopy indicates the formation of a single vortex, with normal conductance at its centre. We observe that for islands with a non-uniform height, H_{C2} varies across the island. The thickest part of the island remains superconducting at higher magnetic field.

TT 33.4 Tue 10:30 HSZ 201

ac susceptibility investigation of vortex dynamics in nearly-optimally doped $Ba(Fe_{1-x}Co_x)_2As_2$ — •Giacomo Prando[1], Romain Giraud[1], Saicharan Aswartham[1], Oleksii Vakaliuk[1], Christian Hess[1], Sabine Wurmehl[1,2], Anja Wolter-Giraud[1], and Bernd Büchner[1,2] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW) Dresden, Germany — [2]Institut für Festkörperphysik, Technische Universität Dresden, Germany

In this contribution we will report about the dynamical features of the flux lines in single crystals of optimally-doped superconducting $Ba(Fe_{1-x}Co_x)_2As_2$ [1]. Investigations were performed by means of magneto-resistivity and first-harmonic ac susceptometry. The extremely high-quality of the sample allows us to enlighten the emergence of a thermodynamical phase transition between the different configuration of vortices in the $H-T$ phase diagram. Insights will be provided into the anomalous features of the magnetic relaxation and into the nature of the glassy phase. As a surprising output, non-negligible values of chemical doping ($x = 10$ %) act as a remarkable low level of quenched disorder for the vortices.

[1] G. Prando et al., Journ. Phys.: Cond. Matt. 25, 505701 (2013)

TT 33.5 Tue 10:45 HSZ 201

Interference of edge and bulk pinning mechanisms in ultra-thin superconducting NbN and TaN mesoscopic bridges — •Konstantin Ilin and Michael Siegel — Iinstitute of Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology (KIT), Hertzstraße 16, 76187 Karlsruhe, Germany

Ultra-thin superconducting films are widely used for development of different types of radiation detectors. Usually, the operation conditions of the detectors are very close to the critical ones. Therefore the critical current density jc and its dependence on temperature and magnetic fields B are interesting not only from the fundamental point of view but very important for different applications. We present results on experimental investigations of jc(B) dependencies in thin film bridges made from NbN and TaN ultra-thin films deposited on sapphire substrates. We have found that in bridges with a width much smaller than the Pearl length and with a thickness about the coherence length (5 nm) the jc(B) dependence is non-monotonic. The critical current density oscillates at B = Bs corresponding to transition from the Meissner (B < Bs) to a vortex state. Moreover in the vortex state at B > Bs the jc(B) dependence is weaker than that one expected from the edge pinning mechanism solely. The observed phenomena could be explained by a significant contribution of a bulk pinning mechanism to the critical state of the current carrying superconducting mesoscopic structures.