TT 27: Superconductivity: Vortex Dynamics, Vortex Phases, Pinning

Time: Wednesday 14:00–15:00 Location: HSZ 105

TT 27.1 Wed 14:00 HSZ 105

Vortex-vortex interaction in thin superconducting films —

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The interaction between Pearl vortices in thin superconducting films is revisited. For infinitely extended films this problem was solved by Judea Pearl [1] who obtained the sheet current $J(r)$ around the vortex and the force $\Phi_0 J(r)$ on a second vortex with magnetic flux Φ_0 and at distance r in terms of the two rarely used Bessel functions S_1 and N_1. It is shown that the interaction potential $V(r)$ and force $-V'(r)$ can be approximated with high precision in the entire range of r by a simple logarithm. This expression directly shows the correct limits $V(r) = (\Phi_0^2/\mu_0)\ln(2.27\Lambda/r)/(2\pi\Lambda)$ for $r \ll \Lambda$ and $V(r) = \Phi_0^2/(\mu_0\pi r)$ for $r \gg \Lambda$. Here $\Lambda = \lambda^2/d$ is the effective penetration depth, λ the London depth, and $d < \lambda$ the film thickness. The effect of finite film size on the vortex interaction is discussed. The interaction now depends not only on the distance r but on both vortex positions and on the film shape [2]. It is shown how the vortex interaction in finite films of any shape and size can be computed.

[1] J. Pearl, Appl. Phys. Lett. **5**, 65 (1964).
[2] E. H. Brandt, Phys. Rev. B **72**, 024529, 1-12 (2005).

TT 27.2 Wed 14:15 HSZ 105

Intrinsic bulk vortex lattice dynamics and tilt moduli revealed by time resolved small angle neutron scattering. —

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In contrast to the local elasticity of crystal lattices, the elasticity of Vortex Lattices (VL) in superconductors is of non-local origin. The VL elasticity, thermal stability, pinning and transport properties can be described by the temperature, field and k-dependent elastic moduli c_{11}, c_{44} and c_{66}, hence yielding important informations on the microscopic nature of superconductivity. Measurements of the VL elastic moduli are traditionally limited to macroscopic transport measurements on bulk samples or microscopic surface sensitive methods such as decoration techniques. We report on a new method to measure the VL tilt modulus c_{44} by means of stroboscopic small angle neutron scattering, combined with a time varying magnetic field setup on an ultrapure niobium single crystal with vanishing pinning. This method allows the microscopic determination of the intrinsic VL elastic moduli in large bulk samples, unhampered by surface effects. We present first data, showing a clear change of the vortex-vortex interaction at the transition from the intermediate mixed state to the mixed state.

TT 27.3 Wed 14:30 HSZ 105

Interplay of thermomagnetic and nonequilibrium effects in nonlocal vortex transport in mesoscopic NbGe channels —

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Amorphous $Nb_{0.7}Ge_{0.3}$, a high-κ type-II superconductor with very low pinning, allows for measurements in the flux-flow regime over large parts of the B-T-phase diagram. When a transport current is driven through a narrow wire (width 250 nm) connected to remote voltage probes via a perpendicular channel (length 2 μm) in presence of an external (out-of-plane) magnetic field, the Transversal Flux Transformer Effect can be used to produce a nonlocal voltage drop on the remote contacts caused by vortex motion in the channel. In the simplest picture, the Lorentz force acting on the vortices in the local wire creates a pressure on the vortices in the channel, such that the mutual vortex repulsion can explain the nonlocal vortex motion. However, detailed measurements of nonlocal DC voltage-current characteristics taken across the whole B-T-plane show several new aspects, including abrupt sign reversals of the vortex motion. This can be understood in terms of an interplay between Lorentz force (low currents) and Nernst effect via local electron heating (high currents) for $T \ll T_c$, and between the Lorentz force (low currents) and a force due to the local suppression of the superconducting gap (high currents) for T close to T_c.

TT 27.4 Wed 14:45 HSZ 105

Observation of nanostripes and -clusters in NEG superconductors —

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Nanostripes are observed in melt-textured and single-crystalline samples of the ternary light rare earth (LRE) compound $(Nd_{0.33}Eu_{0.33}Gd_{0.33})Ba_2Cu_3O_x$ (NEG) by means of atomic force microscopy, scanning tunnelling microscopy at ambient conditions, combined with TEM and electron backscatter diffraction. This enables the observation of several important features: Nanostripes are formed by chains of clusters, representing the LRE/Ba substitution. The periodicity of the nanostripes is found to range between 40 and 60 nm; the shape of the nanoclusters is elliptic with a major axis length between 300 and 500 nm and a minor axis length of about 30 to 150 nm. The dimensions of the nanostripes are similar for both types of NEG samples.