Übungen zu „Elektronische Eigenschaften von Festkörpern II: Supraleitung“ (SS2023)

Exercise sheet 5 · Tutorial on 14.06.2023 · (A.Ustinov/G.Fischer)

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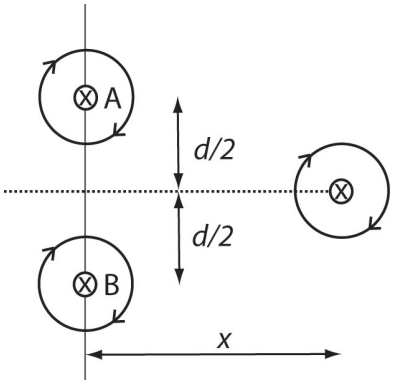
11) Vortex trapping and interactions

a) What is a „pinning center“?

b) There are two vortices in an infinite superconductor, which are trapped (immobilized) at fixed positions, A and B, and such that their distance is d. Assume that a third vortex (with the same direction/sign as the first two) can move along the dashed line perpendicular to the line $\overline{\mathrm{AB}}$.
Calculate the force exerted on the third vortex as a function of the distance x from the line $\overline{\mathrm{AB}}$. All distances in the problem are much smaller than λ and $\kappa \gg 1$.

c) What is limiting the velocity of a moving vortex? What happens for $x \to \infty$?

Make a sketch of two vortices interacting with each other to get the direction of the Lorentz force.



12) Vortex interaction with a cylindrical defect

An infinite superconductor has a cylindrical defect of diameter $d > 2\,\xi$. We consider a vortex with normal core of diameter $\approx 2\,\xi$ interacting with that cylindrical region.

Give

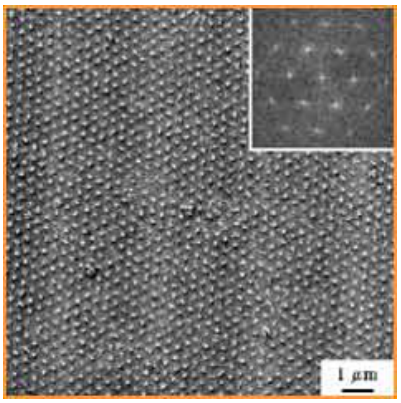
a) the energy of the normal core (per unit length); hint: the energy is the difference of the free energy between normal and superconducting state, given in lecture 2 as energy per unit volume; and

b) the interaction force (pinning force) per unit length between vortex and defect.

c) Estimate the current density j which is required for vortex depinning by the Lorentz force.

13) Distance between vortex lines

The diamagnetic magnetization M of a type II superconductor in an external field, $H_{ext} = 50$ kA/m, is measured $M = 20$ kA/m. And it is: $H_{ext} > H_{c1}$.
Calculate the distance between the (centers) of the flux lines, if you assume one flux quantum Φ_0 per flux line.
Hint: Flux lines keep the same distance from each other and form a triangular lattice (see figure, but there is another distance!). The field within the superconductor is the external field compensated by the diamagnetic magnetization.
[figure: H.F. Hess et al. *Phys. Rev. Lett.* 52, 214 (1989)]



Evaluation of lecture (June 15th) and tutorials (June 14th)

Links also available on ILIAS (until June 16th) ;)

Evaluation for the lecture

Evaluation for the tutorials

Thanks for your participation!