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

Exercise sheet 3 · Tutorial on 17.05.2023 · (A.Ustinov/G.Fischer)

6) Trapping flux

A thin superconductor has a hole of $10\,\mu\text{m} \times 10\,\mu\text{m}$ and is cooled below its transition temperature. During cooling, the earth's magnetic field (strength $H_e \approx 0.5$ G) is oriented perpendicular to the sample.

a) How many flux quanta will be trapped in the hole of the superconductor?

b) In experiments, the random motion of trapped vortices in superconducting circuits is a source of noise due to fluctuating local magnetic fields. Think about how this problem can be avoided.

7) Critical current of a cylindrical wire

Consider a long, superconducting cylindrical wire with radius R within the frame of the London theory, $\lambda \ll R$.

a) How large is the critical current density through the wire as a function of the radius R and the critical magnetic field H_c? Where does the current flow within the wire?

b) Calculate the critical current density through a lead wire with an area of $A = 1$ mm^2 at a temperature of 4.2 K.
For lead (Pb): $H_c(T = 0) = 803$ Oe, $T_c = 7.2$ K, and $\lambda(T = 0) = 39$ nm.

8) On unit systems

a) Give the following physical quantities in SI- and Gaussian cgs-units and the value α with $[\text{quantity}]_{\text{SI}} \mathrel{\widehat{=}} \alpha \cdot [\text{quantity}]_{\text{cgs}}$ for mass m, time t, magnetic induction B, and magnetic field H (e.g.: length: l_{SI} [m] $\mathrel{\widehat{=}} 100 \cdot l_{\text{cgs}}$ [cm]).

b) Give in SI- and in cgs-units:

- Maxwell-equations
- London-equations
- Ginzburg-Landau equations
- London penetration-depth λ
- magnetic flux quantum Φ_0