ETH
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Introduction to Superconductivity
Exercise Sheet 2

HS15
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Exercise 1: Superconducting wires

Current without resistance seems like a dream. But what are the limits? In this exercise you will explore superconducting wires from both a theoretical and an applied perspective, and also learn about the state-of-the-art wires produced in labs today.

(a) We consider an infinitely long superconducting wire of cylindrical shape with radius R. What is the critical current I_c as a function of the radius R and the critical magnetic field H_c?

Comment: The Silsbee criterion states that "... the 'threshold' value of the current is that at which the magnetic field due to the current itself is equal to the critical magnetic field."[1]

(b) Compute the value of the critical current I_c for a lead wire of radius $R = 1$ mm at $T = 4.2$ K.

Comments:

(i) Pb has a critical temperature of $T_c = 7.2$ K and a critical field of $H_c(T = 0) = 800$ Oe.

(ii) The temperature dependence of the critical field is $H_c(T) = H_c(0)(1 - t^2)$, where $t = \frac{T}{T_c}$.

(c) To achieve a high critical current, is it better to use one thick wire or to use many thin wires with the same total cross-section?

(d) In a recent paper by Larbalestier *et al.*[2] the authors describe their newest progress in creating superconducting wires out of high-temperature superconductors. Read the associated 'News&Views' article 'Superconductivity: Squeezing out the current'[3] to find out more.

Comment: The article can be found at http://dx.doi.org/10.1038/nmat3931.

[1] F. B. Silsbee, 'A note on electrical conduction in metals at low temperatures', Journal of the Washington Academy of Sciences 6, 597-602, (1916).

[2] Larbalestier *et al.*, 'Isotropic round-wire multifilament cuprate superconductor for generation of magnetic fields above 30 T', Nature Materials 13, 375-381 (2014).

[3] J. Minervini, Nature Materials 13, 326-327 (2014).