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

Exercise sheet 6 · Tutorial on **21.06.2023** · (A.Ustinov/G.Fischer)

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14) The BCS Theory

Review the basic ideas of the Bardeen-Cooper-Schrieffer theory. Specifically, please comment on:

a) the role of the Debye frequency in the electron-electron interaction,

b) why the formation of Cooper pairs favours electrons of opposite momenta, and

c) the fact that most superconducting metals have a poor normal conductivity.

15) Mind the Gap

a) How does the microscopic BCS theory of superconductivity explain the fact that current can flow without resistance?

b) The BCS theory predicts superconductors to have an energy gap Δ_0. Think about possibilities how one could measure Δ_0.

16) Density of states

Let E_k be the energy of elementary excitations. It describes how much the system energy increases when an extra electron with momentum k is added to the system:
$E_k = \sqrt{\epsilon_k^2 + \Delta_0^2}$ with $\epsilon_k = \frac{\hbar^2}{2m}(k^2 - k_F^2)$.

a) Plot the spectrum of elementary excitations $E_k(k)$.

b) Calculate the density of states of elementary excitations $N_s(E) = d\nu/dE$ as function of energy E and gap Δ_0. Let the density of states near the Fermi level for a normal metal be $N_n(E_F) = d\nu/d\epsilon$.

c) Plot the density of states $N_s(E)$.

d) Calculate how many times the density of states in the elementary excitation spectrum of the superconductor exceeds the density of electron states in the normal metal for excitation energies:

- $1.01 \cdot \Delta_0$,
- $1.50 \cdot \Delta_0$, and
- $2.00 \cdot \Delta_0$.

17) Energy gap of Cadmium

For Cadmium we have $T_c = 0.517$ K. Calculate the energy gap at $T = 0$ K according to the BCS theory and compare the result with the experimental value of $1.5 \cdot 10^{-4}$ eV. Determine the wavelength of a photon, which is able to break a Cooper pair in Cadmium.

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!