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Theory of Superconductivity, Frühjahrsemester 2023

Blatt 5

Abgabe: 13.4.23, 12:00H (Treppenhaus 4. Stock)
Tutor: Tobias Nadolny, Zi.: 4.48

(1) **Tunneling between two superconductors** (5 Punkte)

In the lecture we discussed the formula for the tunneling current between two superconductors (that includes also the cases of normal-normal or normal-superconductor tunneling by setting Δ_1 and/or Δ_2 to 0):

$$IR_n e = \int_{-\infty}^{\infty} dE \frac{N_{1s}(E)}{N_{1n}(0)} \frac{N_{2s}(E+eV)}{N_{2n}(0)} [f(E) - f(E+eV)] \,.$$

Here, $R_n = 1/G_{nn}$ is the resistance of the junction in the normal state, and $N_{is}(E) = |E|/\sqrt{E^2 - \Delta_i^2}$ for $|E| > \Delta_i$ and 0 otherwise, $i = 1, 2$.
(Note the absolute value signs in the numerator!)

(a) Evaluate this formula numerically for $2\Delta_1 = \Delta_2 = \Delta$ and plot I as a function of voltage V for different temperatures in the range $k_B T \in [0, \Delta]$ (you can assume that Δ is approximately temperature-independent in this temperature range). Use limiting values (like $\Delta_1 = \Delta_2 = 0$) to check your numerics.

(b) Show that $I(V) = -I(-V)$.

(2) **Electromagnetic response** (5 Punkte)

In the lecture we discuss the kernel $K(\mathbf{q}, T)$ that connects the Fourier components of current density and vector potential:

$$\mathbf{J}(\mathbf{q}) = -\frac{1}{\mu_0} K(\mathbf{q}, T) \mathbf{a}(\mathbf{q}) \,.$$

Read and understand Sections 3.10.1 to 3.10.4 of Tinkham and repeat the most important findings in your own words or figures.