

# Theory of Superconductivity, Frühjahrsemester 2026

## Blatt 4

Abgabe: 26.03.26, 12:00H (auf adam oder Treppenhause 4. Stock)

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### (1) Tunneling between two superconductors

The quasiparticle tunneling current between two superconductors (that includes also the cases of normal-normal or normal-superconductor tunneling by setting  $\Delta_1$  and/or  $\Delta_2$  to 0) is given by

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

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  $\Delta$  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

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.