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Exercises Condensed Matter Physics (Experimentalphysik 5c), WS16/17

Bonus (numerical) Exercise

1) **Temperature dependence of the energy gap Δ(T) of a superconductor** (8 credits)

For the calculation of $\Delta(T)$ the BCS gap equation needs to be solved:

$$\frac{1}{N_0 V} = \int_0^{\hbar\omega_D} \frac{\tanh\left(\sqrt{\Delta(T)^2 + \xi^2} / 2k_B T\right)}{\sqrt{\Delta(T)^2 + \xi^2}} d\xi$$

N_0 and V are the unknown density of states at the Fermi energy and the electron-electron interaction strength. However, $\Delta(T)/\Delta(0)$ is a parameter free function of T/T_c!

a) Describe in keywords an algorithm, which solves the gap equation.

b) Calculate $\Delta(T)$ numerically, e.g. using Mathematica (available as ZDV app).

Hints: How do you need to change Δ if T is changed, but $1/(N_0V)$ remains constant?

Define $\Delta(0) = 1$ and use for the energy and k_BT identical arbitrary units.

Choose the integration limit $\hbar\omega_D >> \Delta$, so that its specific value does not influence the result.

The help function of Mathematica is quite good. All Mathematica commands begin with a capital letter. To execute a calculation you need to hit SHIFT+Enter. You may want to use the commands: NIntegrate, Tanh, Sqrt, While, Append, ListPlot