Solid State Theory
Exercise 12

Exercise 12.1 Conductivity tensor

Calculate explicitly, in the static and $T = 0$ limit, the conductivity tensor

$$\sigma_{\alpha\beta} = -\frac{e^2}{4\pi^3} \int d^3k \frac{\tau(\epsilon_{\boldsymbol{k}})}{1 - i\omega\tau(\epsilon_{\boldsymbol{k}})} \frac{\partial f_0(\varepsilon_{\boldsymbol{k}})}{\partial \varepsilon_{\boldsymbol{k}}} v_{\alpha\boldsymbol{k}} v_{\beta\boldsymbol{k}}, \tag{1}$$

for a dispersion relation of the form

$$\varepsilon_{\boldsymbol{k}} = \sum_{\alpha=x,y,z} \frac{\hbar^2 k_\alpha^2}{2m_\alpha}. \tag{2}$$

Exercise 12.2 Residual Resistivity of Copper

Recapitulate Section 6.3.1 and try to find an explanation for the data in Table 1. What is the major reason for the increase of the resisitivity?

Impurity	Resistivity (per 1% of impurity atoms) $\rho/(10^{-8}\Omega m)$
Be	0.64
Mg	0.6
B	1.4
Al	1.2
In	1.2
Si	3.2
Ge	3.7
Sn	2.8
As	6.5
Sb	5.4

Table 1: Residual resistivity of Cu for different impurities (From Landolt-Börnstein Tables, Vol 15, Springer, 1982)

Hint: In analogy to doped semiconductors, assume that an impurity atom will adjust itself corresponding to its neighbourhood. This means that it rejects all electrons from its outer shells in order to match the occupancy of its surrounding atoms. Hence the impurity is left with an effective nuclear charge Z. The explanation of the above table lies in this fact.

Contact person:
Evert van Nieuwenburg, HIT K23.7 (evertv@itp.phys.ethz.ch)