Intro. to Solid state
Exercise 2

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Question 1

Given that:

$$\bar{J} = n_e q_e \bar{v}_e + n_h q_h \bar{v}_h.$$

What is the electrical conductivity σ under a DC field?

Solution:

Drude equation of motion:

$$\frac{d}{dt}\bar{p} = -\frac{\bar{p}}{t} + q\bar{E}.$$

So for every charge carier:

$$\bar{p}_i = q_i \tau \bar{E}.$$

And if we multiply by the correct units:

$$n_i q_i \bar{v}_i = \frac{n_i q_i^2 \tau}{m_i}\bar{E}.$$

We get exactly the equation for the flow $\bar{J}$:

$$\bar{J} = \frac{n_i q_i^2 \tau}{m_i}\bar{E}.$$

And if we add up for the two charge cariers:

$$\bar{J} = \left(\frac{n_e q_e^2 \tau_e}{m_e} + \frac{n_h q_h^2 \tau_h}{m_h}\right)\bar{E}.$$

We get:

$$\sigma = \frac{n_e q_e^2 \tau_e}{m_e} + \frac{n_h q_h^2 \tau_h}{m_h}.$$

As expected if there's no interaction between the electrons and the holes the total conductivity is the sum of the two independet conductivities.

Question 2

Show that:

$$\bar{J} = \frac{e\tau}{m} k_B T \nabla n.$$

Exercise 1

hello