Karlsruher Institut für Technologie
Institut für Theorie der Kondensierten Materie

Theorie der Kondensierten Materie II SS 2017

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1. Drude conductivity: (25 + 15 = 40 Punkte)

In the lecture, we have considered the conductivity of the non-interacting electron system in the presence of a disorder potential, assuming the impurity scattering to be isotropic. In this case, we have identified the diagram corresponding to the Drude approximation.

(a) Use the rules ofthe diagrammatic technique to evaluate the Drude conductivity.

(b) Discuss the result in two- and three-dimensional systems. In particular, show that the Drude conductivity satisfies the Einstein relation

$$\sigma_0 = e^2 D \nu_0,$$

where ν_0 is the density of states at the Fermi level and D is the diffusion coefficient. What is the expression for D in two and three dimensions?

Also, consider the alternative expression

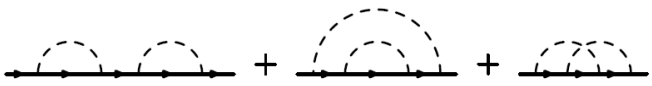
$$\sigma_0 = \frac{e^2}{\pi} E_F \tau.$$

When is this valid?

2. Non-crossing approximation: (30 + 30 = 60 Punkte)

In the lecture, you learned that disorder averaging is typically performed within the "non-crossing approximation", i.e. that one may disregard diagrams with crossed impurity lines.

Consider the second-order contributions to the self-energy of electrons.



(a) Consider the diagram with crossed impurity lines. Show, that this diagram gives a contirbution, that contains an extra smallness. Identify the small parameter.

(b) Consider the middle ("rainbow") diagram. Use the "graphic summation" arguments to show that this is the first diagram in the subseries that can be understood as a self-consistency condition. Write down the self-consistency condition and show that the result is equivalent to what was obtained in the lecture.