Karlsruher Institut für Technologie

Institut für Theorie der Kondensierten Materie

Übungen zur Theorie der Kondensierten Materie II SS 16

Prof. J. Schmalian

M. S. Scheurer, B. Jeevanesan

Blatt 11

Besprechung 08.07.2016

---

1. Hall conductivity of graphene (18 Points)

As you learned in the lecture, the conductivity tensor can be computed by the formula

$$\sigma_{\alpha\beta}(\omega) = -\frac{\mathrm{Im}[\Pi^r_{\alpha\beta}(\omega)]}{\omega} \tag{1}$$

with

$$\Pi_{\alpha\beta}(\Omega_m) = -T \sum_n \int \frac{d^2k}{(2\pi)^2} \mathrm{Tr}\left[\mathcal{G}_k(\omega_n + \Omega_m) J_\alpha \mathcal{G}_k(\omega_n) J_\beta\right]. \tag{2}$$

The current operators are given by $J_\alpha = ve\sigma_\alpha$ at the K point and by $J_\alpha = ve\sigma^*_\alpha$ at the K' point, with $\alpha = x, y$. In the lectures the diagonal components of $\sigma_{\alpha\beta}$ were computed. Now we will find the off-diagonal components, the so-called Hall conductivity. The propagator $\mathcal{G}_k(\omega_n)$ is given by

$$\mathcal{G}_k(\omega_n) = -\frac{i\omega_n + v\boldsymbol{k}\cdot\boldsymbol{\sigma} + m\sigma^z}{\omega_n^2 + (vk)^2 + m^2}. \tag{3}$$

The massless Dirac propagator is obtained in the limit $m \to 0$. This mass will be needed to regulate the result that you will obtain in the following.
Compute σ_{xy} using formula (1). As a final result you should obtain at the K point the formula $\sigma_{xy} = e^2/(2\pi\hbar)\mathrm{sgn}(m)$ and at K' the formula $\sigma_{xy} = -e^2/(2\pi\hbar)\mathrm{sgn}(m)$. This gives a total Hall conductivity of 0.