

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

1. ^3He (4 credits)

^3He atoms are spin $\frac{1}{2}$ particles, i.e. Fermions. Liquid ^3He has a density of $n = 81\text{kg/m}^3$ near absolute zero temperature. Consider this liquid as a gas of free spin $\frac{1}{2}$ particles.

Calculate the Fermi energy E_F , Fermi temperature T_F and average zero-point energy per atom.

For the calculation of $E_F(n)$, calculate first $k_F(n)$. For the calculation of the average energy per atom, calculate first the energy per volume using the known density of states of a Fermi gas:

$$D(E) = \frac{3}{2} \frac{n}{E_F} \left(\frac{E}{E_F} \right)^{1/2}$$

2. Bloch wave (1 credit)

Show the equivalency of the alternative ways eq. (30) and eq. (33) to define a Bloch state.

3. Crystal momentum (2 credits)

Show that the crystal momentum of electrons in a periodic potential is NOT a constant of motion.

Evaluate the commutation relation $[H, p] = Hp - pH$ for electrons in a general potential $V(r)$, which has to be shown to be non-zero.