

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

1) Specific heat after Dulong-Petit (2 credits)

Within the classical Dulong-Petit approximation, the specific heat of all solids amounts to $c_v=3nk_B$. However, as the density of the materials varies, the heat capacity varies as well. Calculate the heat capacity C_V of 1kg of Cu and 1kg of Al.

2) Schottky-Anomaly of the specific heat (4 credits)

The N lattice atoms of a crystal provide additional to the translational degrees of freedom inner degrees of freedom, which also contribute to the specific heat. Suppose a lattice atom has two different orientations of its magnetic moment in a magnetic field. The difference in energy of those two states amounts to $k_B\Delta$. The ratio of the state occupation is given by a Boltzmann factor $\exp(-k_B\Delta/k_B T)$.

a) Show, that the resulting contribution to the specific heat is given by

$$c_V = Nk_B \frac{(\Delta/T)^2 e^{\Delta/T}}{(1 + e^{\Delta/T})^2}$$

b) Draw this $c_V(T)$ -curve and discuss, in which temperature range the contribution to the specific heat of the solid is relevant ($\Delta \cong 1\text{K}$).

3) Phonon density of states (3 credits)

A 1-dimensional chain of length L consists of N identical atoms separated by the distance a . In this case a phonon dispersion relation of $\omega(\mathbf{k}) = \omega_0|\sin(\mathbf{ka}/2)|$ is obtained.

Calculate the density of states of the phonons.