Háskóli Íslands
Raunvísindadeild
Eðlisfræði

Haust 2014

Eðlisfræði þéttefnis I

Dæmablað 7

Skilafrestur 14. October 2014 kl. 15:00

1. **Thermal conduction** (10)

   Explain why electrons carry a net energy but not a net current in the case of thermal conduction.

2. **Dispersion relation** (15)

   Consider a linear chain in which alternate ions have mass M_1 and M_2, and only nearest neighbors interact.

   (a) Show that the dispersion relation for normal modes is

   $$\omega^2 = \frac{K}{M_1 M_2}\left(M_1 + M_2 \pm \sqrt{M_1^2 + M_2^2 + 2M_1 M_2 \cos ka}\right)$$

   (b) Discuss the form of the dispersion relation and the nature of the normal modes when $M_1 \gg M_2$. (i.e. calculate and draw the normal modes)

   (c) Compare the dispersion relation with that of the monatomic linear chain when $M_1 \sim M_2$. (i.e. calculate and draw the normal modes)

3. **Low-temperature specific heat in d dimensions and for nonlinear dispersion** (15)

   Consider small lattice vibrations in a d-dimensional crystal in harmonic approximation.

(a) For the Debye model, i.e. a linear dispersion $\omega = c\,|k|$ of all phonon modes, calculate the phonon density of states and show that it varies as ω^{d-1}. What is the Debye frequency ?

(b) Determine the phonon contribution to low-temperature specific heat.

(c) Investigate what would happen for a nonlinear phonon dispersion $\omega \sim |k|^{\nu}$ (anomalous sound). Show that the low-temperature specific heat would vanish as $T^{d/\nu}$ in d dimensions.