University of Regensburg Summer Term 2014

Quantum Theory of Condensed Matter I

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5.1.01 Mondays 10:15
9.2.01 Tuesdays 12:15

Sheet 10

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1. Specific heat of magnons

In the lattices of ferromagnetic ions collective excitations of spins, called also *spin waves* can arise. The quasiparticles associated with these waves are called *magnons*, and they possess spin $s = 1$. The dispersion of magnons at low energies is given by

$$E(\vec{q}) \approx 2JSa^2q^2,$$

where $J > 0$ is the exchange interaction parameter, S is the spin of the ions constituting the lattice and a is the lattice constant.

1. What is the energy dependence of the density of states of magnons? The system is 3-dimensional. **(4 Points)**
2. The dependence on temperature of the energy and specific heat carried by the magnons has the form $E \sim T^x, C \sim T^y$. Calculate x and y. (Hint: performing the actual integration is not necessary if the integral is expressed in dimensionless variables.) **(4 Points)**
3. Compare the results with those obtained for phonons. Discuss the differences between these two types of particles. **(4 Points)**

2. Thermodynamics of a semiconductor

(Oral) Consider the following model of semiconductor with constant density of states for the valence and conduction band:

$$\mathrm{DOS}(E) = \begin{cases} \frac{1}{E_0} & \text{for } 0 < E < E_0 \text{ and } E_0 + \Delta < E < 2E_0 + \Delta \\ 0 & \text{elsewhere} \end{cases}$$

Assume that the chemical potential lies well inside the gap and calculate for this model the temperature dependence of the specific heat in the limit of small temperatures.

Frohes Schaffen!