MATERIALS PHYSICS II FALL 2006 HOMEWORK PROBLEMS 9

Return to Michael by Wednesday 22.11.2006 at noon

1. *Magnon dispersion relation.* Read the section 7.2.5.4 (pages 620-624) *Spin waves: magnons* from Elliot and derive the magnon dispersion relation

$$\hbar\omega_k = 2JS(1 - \cos(ka)).$$

(3 points)

2. Work through the *Cooper problem* (Elliot, problem 6.15 on p. 531) Note a misprint in Eq (1): "Z" should be "2". Note also that in Eq (4) on p. 531 the density of states is

$$g(\varepsilon) = \int \frac{\mathrm{d}S_\varepsilon}{4\pi^3|\nabla_k \varepsilon(k)|},$$

which may well be approximated by its value at Fermi-level, $g \approx g(\varepsilon_F)$. The Cooper problem is also discussed in Kittel, Appendix H. (**3 points**)

3. *The Meissner effect* Explain why a small supercoducting object can "levitate" on top of a permanent magnet (see Elliot figure 6.69). Derive a result for the levitation hight:

$$z_0 = [B^2(a)a^2/\mu_0\rho g]^{1/3}$$

where a is the thickness of the magnet, ρ is the mass density of the superconductor and g the gravitational constant. If you would like to get an object made out of Niobium (Nb) to levitate 5 cm above a magnet of thickness of 2 cm, how strong has the magnetic flux density to be (in Tesla) at the top surface of the magnet? (**3 points**)