PHYS 530: Problem Set 9

Due: 4:30 pm, 9 April 2013

If the answer is shown, all the marks will be given for the derivation not for writing down the answer. In your solutions, you may need to make some assumptions. Make sure that you formulate all of them clearly.

1. [10] Solve problem 8.6 in Pathria's book.

   Show that the velocity of sound w in an ideal Fermi gas is given by

   $$w^2 = \frac{5kT}{3m}\frac{f_{5/2}(z)}{f_{3/2}(z)} = \frac{5}{9}\langle u^2\rangle\,, \tag{1}$$

   where $\langle u^2\rangle$ is the mean squared speed of the particles in the gas. Evaluate w in the limit $z \to \infty$ and compare it with the Fermi velocity u_F.

2. [6] Prove that the magnetic susceptibility associated with Pauli paramagnetism is given by

   $$\chi = \lim_{B\to 0}\frac{dM}{dB} = \frac{n\mu^{*2}}{kT}\frac{f_{1/2}(z)}{f_{3/2}(z)}\,, \tag{2}$$

   where n is the electron density; that is, the total number of electrons per unit volume. *Hint:* Consider electrons with + magnetic moment parallel to B and − magnetic moment antiparallel to B as two different species, write $N_\pm$ in terms of one or more of the f_ν functions, and express the magnetisation in terms of N_+, N_-, and the Bohr magnetic moment μ^*. Finally, make use of the fact that B is infinitesimal. In doing this, you will have to somehow account for the magnetic energy $\mu^* B$ in the chemical potential.