8.512 Theory of Solids II
Spring 2009

8.512 Theory of Solids II **Problem Set 6** **Due March 31, 2008**

1. The response function $K_{\mu\nu}$ defined by

$$J_\mu = -K_{\mu\nu} A_\nu$$

can be decomposed into the transverse and longitudinal parts.

$$K_{\mu\nu}(\boldsymbol{q}, \omega) = \left(\delta_{\mu\nu} - \frac{q_\mu q_\nu}{q^2}\right) K_\perp(q, \omega) + \frac{q_\mu q_\nu}{q^2} K_\parallel(q, \omega)$$

(a) Starting from the linear response expression, calculate $K_\perp(q, \omega = 0)$ for a free Fermi gas. [It may be useful to choose $\boldsymbol{q} = q\hat{z}$ and compute K_{xx}.]

(b) Using the results from (a), show that the Landau diamagnetic susceptibility (including spin degeneracy) is given by

$$\chi_D = -\frac{e^2 k_F}{12\pi^2 mc^2}$$

Check that this is $-1/3$ of the Pauli spin susceptibility. For an alternative derivation using Landau levels, please study the discussion in Landau and Lifshitz's *Statistical Physics,* Vol. 1, p.173.