MID-TERM -1

Physics 752, Fall, 2002

1. Find the expression for the particle-hole bubble $\Pi(q, 0)$ at arbitrary $q$ in two dimensions.

2. The optical conductivity $\sigma(\omega)$ is expressed via the particle-hole bubble $\Pi(q = 0, \omega) = \Pi(\omega)$ as

$$\sigma(\omega) = -\frac{\omega_p^2}{4\pi} \frac{Im\Pi(\omega)}{\omega}$$

(1)

where $\omega_p$ is the plasma frequency. Suppose that $\Sigma(k, \omega) = i\gamma$ (impurity scattering). Find $\sigma(\omega)$.

3. For the problem (2), compute

$$\int_0^\infty \sigma(\omega)d\omega$$

(2)

(hint - use Kramers-Kronig relations). Explain the result.

4. Show that

$$S(k) = \int_{-\infty}^{\infty} S(k, \omega) \frac{d\omega}{2\pi},$$

(3)

where

$$S(k, \omega) = \hbar \left( \coth \frac{\hbar \omega}{2T} \right) Im\chi(k, \omega),$$

(4)

can be re-expressed as

$$S(k, \omega) = T \sum_n \chi(k, \omega_n)$$

(5)

where $\omega_n$ are Matsubara frequencies

5. Find the Green’s function of a phonon field (see §31 in Landau).