

PHYSICS 211B : CONDENSED MATTER PHYSICS
HW ASSIGNMENT #3

(1) For the Hamiltonian

$$\hat{H}(t) = \hat{H}_0 - \sum_i \hat{Q}_i \phi_i(t) \quad ,$$

the response to second order may be written

$$\langle \Psi(t) | \hat{Q}_i | \Psi(t) \rangle = \int_{-\infty}^{\infty} dt' \chi_{ij}(t, t') \phi_j(t') + \int_{-\infty}^{\infty} dt' \int_{-\infty}^{\infty} dt'' \chi_{ijk}^{(2)}(t, t', t'') \phi_j(t') \phi_k(t'') + \mathcal{O}(\phi^3) \quad .$$

Find an expression for the nonlinear response tensor $\chi_{ijk}^{(2)}(t, t', t'')$ in terms of the spectral properties of \hat{H}_0 .

(2) Sketch the spread of particle-hole excitation frequencies, depicted for a $d = 3$ Fermi gas in Fig. 9.3 of the lecture notes, in dimensions $d = 2$ and $d = 1$.

(3) Using the RPA and the SMA, determine the plasmon dispersion for the two-dimensional electron gas with interactions $u(r) = e^2/r$.