Homework set 10, Chapter 8, due Nov. 18th, 2010.

PROBLEMS

8.1. Use the eigenstates of the hydrogen atom to evaluate its atomic polarizability $\alpha$.

8.2. If atomic hydrogen formed a cubic lattice, what would its static dielectric constant be?

8.4. A degenerate polar semiconductor contains $n_0$ free electrons per unit volume in the conduction band. Its dielectric function $\varepsilon(\omega)$ is given by

$$\varepsilon(\omega) = \varepsilon_\infty \frac{\omega^2 - \omega_L^2}{\omega^2 - \omega_T^2} - \frac{\omega_p^2}{\omega^2}$$

where $\omega_L$ and $\omega_T$ are the LO and TO phonon frequencies, and $\omega_p = \sqrt{\frac{4\pi n_0 e^2}{m}}$.

(a) Show that $\varepsilon(\omega)$ can be written as

$$\varepsilon(\omega) = \varepsilon_\infty \frac{(\omega^2 - \omega_-^2)(\omega^2 - \omega_+^2)}{\omega^2(\omega^2 - \omega_T^2)}$$

and determine $\omega_-^2$ and $\omega_+^2$.

(b) Make a sketch of $\varepsilon(\omega)$ versus $\omega$; be sure to indicate the locations of $\omega_T$, $\omega_L$, $\omega_-$, $\omega_+$, $\varepsilon_0$, and $\varepsilon_\infty$.

(c) Determine the dispersion relation of the longitudinal and transverse modes, i.e. $\omega$ as a function of $q$.

(d) In which regions of frequency are the transverse waves unable to propagate?

(e) Consider a vacuum–degenerate polar semiconductor interface. Use the results obtained in the text to determine the dispersion relations of the surface modes.

(f) Make a sketch of $\omega$ versus $q_y$ ($q_y$ is parallel to the interface) for these surface modes and for the bulk modes which have $q_z = 0$. 