# PHYC 569, Advanced Topics in Modern Optics

***(Laser Physics II: PHYC/ECE 564)***

**Fall 2016**

*Homework #2, Due Tuesday Sept. 20*

Instructor: M. Sheik-Bahae

**1.** Show that the interband absorption coefficient of semiconductors can be given as:

$$\alpha(h\nu) = A_0 \frac{E_g}{n_0}\frac{\sqrt{x-1}}{x} \quad (1)$$

where $\alpha$ is in cm$^{-1}$, $E_g$ is in eV and $x=h\nu/E_g$. Evaluate $A_0$ in the effective mass approximation.

**2.** (a) Derive the formula for thermally-ionized electron-hole concentration in an intrinsic (i.e. undoped) semiconductor in terms of $E_g$, kT, $n_0$ and $E_p$. This is called intrinsic carrier concentration $n_i$.

(b) Evaluate $n_i$ for InSb ($E_g$=0.18 eV), GaAs ($E_g$=1.42 eV) and ZnSe ($E_g$=2.6 eV) at room temperature (T=300K). Take $E_p \cong 21$ eV for all semiconductors.

**3.** Strictly speaking, the energy-momentum dispersion relation for a two band (c and v) system is not purely parabolic and is given by the equation (e.g. see S. L. Chuang, 4.1.16):

$$\left[E(k)-\frac{\hbar^2k^2}{2m_0}\right]\cdot\left[E(k)-\frac{\hbar^2k^2}{2m_0}-E_g\right]=\frac{\hbar^2}{m_0^2}|p_{cv}\cdot k|^2$$

(a) Show that $E_c(k)-E_v(k)=E_g\sqrt{1+\frac{4\hbar^2|k.p_{cv}|^2}{m_0^2E_g^2}}=E_g\sqrt{1+\frac{2\hbar^2k^2E_p}{m_0E_g^2}}$ for $k \| p_{cv}$ (light holes)

(b) Calculate the joint density of state $\rho_{cv}(E)$, and the absorption coefficient $\alpha_0(h\nu)$ for such non-parabolic bands. Compare your result with that given by Eq.(1) by plotting the two absorption coefficients versus photon energy..