ECE 656: Fall 2009
Lecture 25 Homework
(Revised 10/29/09)

1) In Lecture 24, we worked out the scattering rate due to acoustic phonon deformation potential scattering. Repeat that calculation, but do not assume that the acoustic phonons are elastic.

   To simplifiy thje calculation, just compute the scattering rate due to scattering by spontaneous emission of acoustic phonons.

L25

$$S(p,p') = \frac{1}{\Omega} C_\beta \left(N_\omega + \tfrac{1}{2} \mp \tfrac{1}{2}\right) \delta\left(\pm\cos\theta + \frac{\hbar\beta}{2p} \mp \frac{\omega}{v\beta}\right)$$

$$C_\beta = \frac{\pi}{\hbar\rho v\omega\beta} |K_\beta|^2 = \frac{\pi D_A^2 \beta^2}{\hbar \rho v \omega \beta} = \frac{\pi D_A^2}{\hbar \rho v v_s}$$

$$N_\omega = \frac{1}{e^{\hbar\omega/kT} - 1}$$

$$\frac{1}{\tau} = \frac{1}{4\pi^2} \int_{\beta_{min}}^{\beta_{max}} \frac{\pi D_A^2}{\hbar \rho v v_s} \left(N_\omega + \tfrac{1}{2} \mp \tfrac{1}{2}\right) \beta^2 \, d\beta$$

$$= \frac{1}{4\pi^2} \int_{\beta_{min}}^{\beta_{MAX}} \frac{\pi D_A^2}{\hbar \rho v v_s} \left(N_\omega + \tfrac{1}{2} \mp \tfrac{1}{2}\right) \beta^2 \, d\beta$$

$$= \frac{1}{4\pi^2} \int_{\beta_{min}}^{\beta_{MAX}} \frac{\pi D_A^2}{\hbar c_\ell v} \left(N_\omega + \tfrac{1}{2} \mp \tfrac{1}{2}\right) \beta^2 \, d\beta$$

$$= \frac{D_A^2}{4\pi \hbar c_\ell v} \int_{\beta_{min}}^{\beta_{MAX}} \left(N_\omega + \tfrac{1}{2} \mp \tfrac{1}{2}\right) \beta^2 \, d\beta$$

for ABS $\qquad\qquad$ for EMS

$$\omega = v_s \beta \qquad \int_{\beta_{min}}^{\beta_{max}} \frac{\beta^2 d\beta}{e^{\hbar v_s \beta/kT} - 1} \qquad \int_{\beta_{min}}^{\beta_{MAX}} \left(\frac{1}{e^{\hbar v_s \beta/kT}} + 1 \right) \beta^2 d\beta$$

let's assume that the +1 EMS term dominates

$$\frac{1}{\tau} \simeq \frac{D_A^2}{4\pi\hbar C_e v} \int_{\beta_{min}}^{\beta_{MAX}} \beta^2 d\beta$$

$$\simeq \frac{D_A^2}{4\pi\hbar C_e v} \left(\frac{\beta_{max}^3}{3} - \frac{\beta_{min}^3}{3} \right)$$

$$\beta_{max} = 2p(1 - v_s/v) \qquad v > v_s$$

$$\beta_{min} = 0$$

$$\frac{1}{\tau} \simeq \frac{D_A^2}{4\pi\hbar C_e v} \times \frac{1}{3} \times (1 - v_s/v)^3 \times 8p^3$$

$\frac{1}{2} m v^2 = E$

$$\simeq \frac{2}{3} \frac{m^* D_A^2}{\pi\hbar C_e} p^2 (1 - v_s/v)^3$$

$\frac{p^2}{2m} = E$

2)

$$\simeq \frac{4}{3} \frac{m^{*2} D_A^2}{\pi\hbar C_e} E \left(1 - v_s/\sqrt{2E/m^*}\right)^3 \quad //$$