1. **Neutron Scattering**

Consider an inelastic scattering experiment performed with a triple axis neutron spectrometer. Let the non-relativistic incident neutron energy be 0.02 eV. The second axis of the spectrometer is set such that incident neutron is fired along the [100] axis of the crystal (perpendicular to the (100) planes.)

(a) What is the value of the incident neutron wavelength ?

(b) Show that q, the magnitude of the scattered neutron wavevector, is related to the incident neutron wavevector q via the relation $q = q'(\cos\theta - \sin\theta)$ when any phonon which has wavevector $\frac{1}{\sqrt{2}}(k, k, 0)$ is absorbed. θ is the angle between the incident neutron direction and the scattered neutron direction. Assume that $\vec{G} = 0$ for this scattering event.

(c) Show that

$$q^2 = q'^2(1 - \sin 2\theta)$$

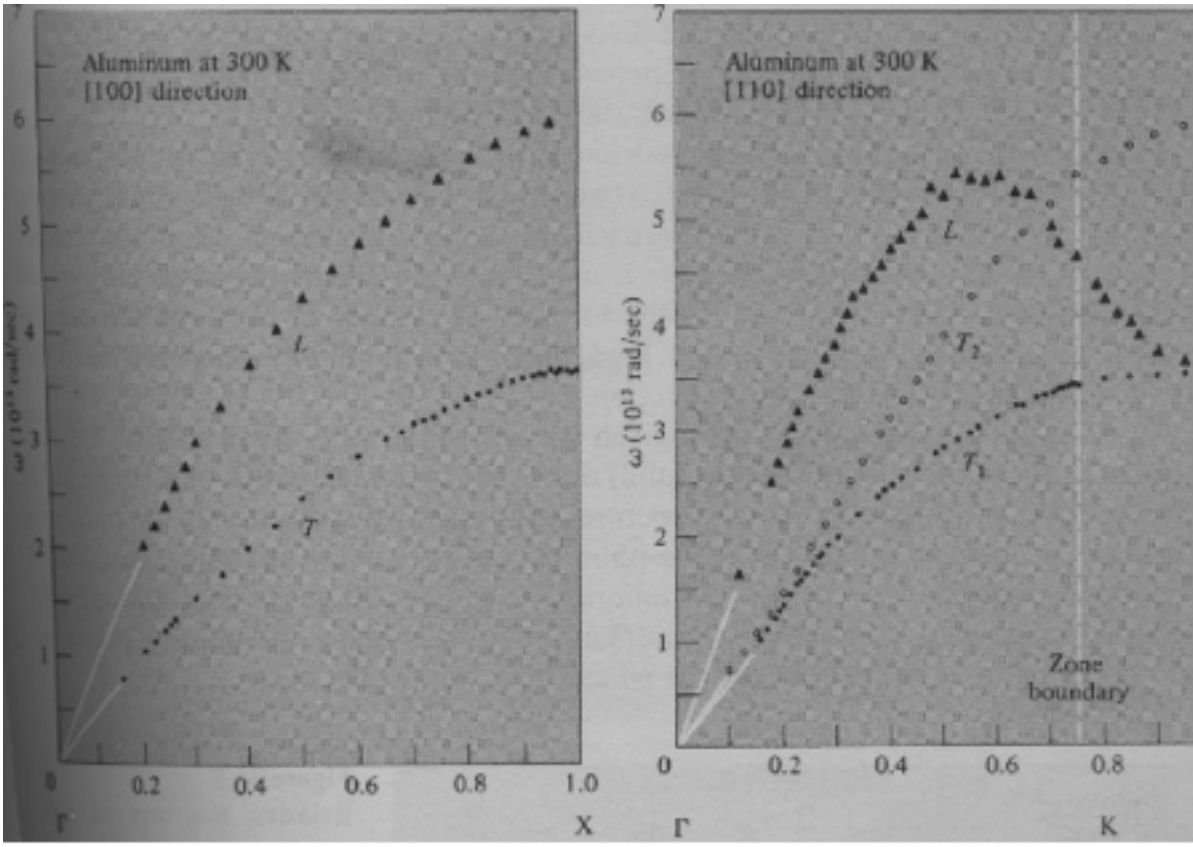
(d) Show that

$$\sin 2\theta = \frac{R}{1+R}$$

when a longitudinal phonon propagating in the (110) direction from is absorbed. Here

$$R = \hbar\omega(\vec{k})/\frac{\hbar^2 q^2}{2m}$$

.


Aluminum at 300 K
[100] direction
L
T
0
0.2
0.4
0.6
0.8
1.0
Γ
X
Aluminum at 300 K
[110] direction
L
T2
T1
Zone
boundary
ω (10^13 rad/sec)
1
2
3
4
5
6
7
0
0.2
0.4
0.6
0.8
Γ
K

(e) Pretend that you are scattering neutrons from an Aluminum crystal (fcc structure). The incident neutron has $\vec{q} = q(1, 0, 0)$. You are set up to observe the scattered neutron after absorption of one phonon from the longitudinal branch with wavevector $\vec{k}$ at the K point of the Brillouin zone.

   i. What is the energy of the absorbed phonon? (use the dispersion curve shown above)

   ii. What is the energy of the scattered neutron?

(f) For the scattering process described in (e) find the angle θ at which the scattered neutron is observed with respect to the incident neutron if one phonon from the K point in the Brillouin zone is absorbed.